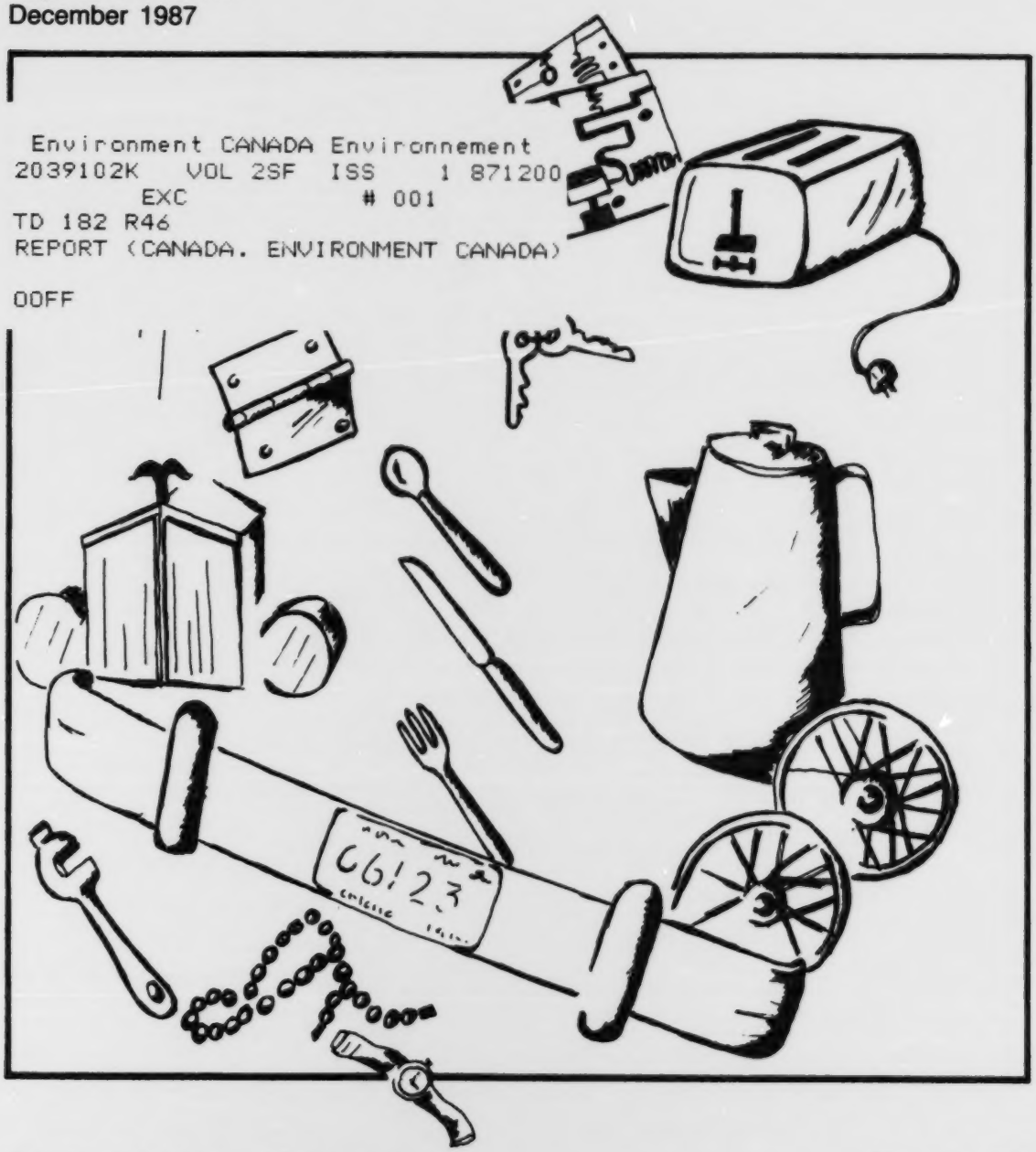
Overview of the Canadian Surface Finishing Industry

Status of the Industry and Measures for Pollution Control

Report EPS 2/SF/1
December 1987



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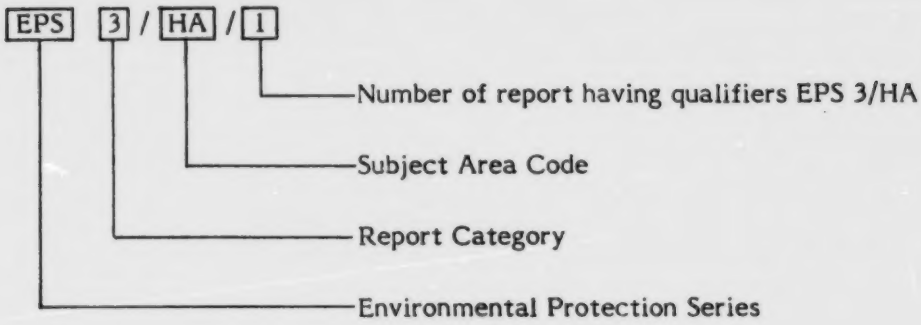

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OVERVIEW OF THE CANADIAN SURFACE FINISHING INDUSTRY

Status of the Industry and Measures for Pollution Control

by

Chemical Industries Division
Environmental Protection
Conservation and Protection
Environment Canada

and

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Report EPS 2/SF/1
December 1987

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ABSTRACT

Surface finishing processes are known to produce wastewaters that contain potentially toxic pollutants such as metals and organic solvents, as well as acidic wastes which, if discharged to municipal sewers, can corrode sewer lines and damage treatment facilities. Sludge handling and disposal, as well as the sources and treatment of air emissions, are two further areas of concern associated with this industry. This report presents the results of a national survey completed in 1983-84 which addressed:

1) surface finishing processes;
2) solid, liquid and atmospheric waste generation and treatment; and
3) regulations and compliance at the federal, provincial and municipal levels.

The main objective was to identify potential environmental problems and recommend preventive or remedial action.

There are an estimated 644 surface finishing operations in Canada; 539 completed and returned the survey questionnaire. Survey results confirmed that most of the liquid and solid wastes from surface finishing operations are hazardous. Only about 60 percent of this hazardous waste is being handled and disposed of as such. Some untreated discharges of wastewater, spent process baths and sludges are being directed to sanitary sewers or directly to water courses. Off-site waste disposal appears to be decreasing and on-site disposal and/or sewer discharge appears to be increasing.

The Federal Metal Finishing Liquid Effluent Guidelines for suspended solids, chromium, cyanide, copper, lead, nickel and zinc, established under the Fisheries Act in 1977, are not being met in one or more provinces. Provincial and municipal regulations are effective only where enforcement activities are carried out regularly.

Recommendations include that the federal government:

1) promote the use of treatment and recovery technology through demonstration projects;
2) determine the significance of air emissions from surface finishing operations;
3) assess the options of on-site and off-site disposal of hazardous wastes from surface finishing operations;
4) encourage municipalities and provinces to enact and enforce environmental protection legislation specific to this industry; and,
5) in cooperation with other governments and industry, develop and promote environmental training material for owners, equipment operators and workers in surface finishing plants.

RÉSUMÉ

On sait que les procédés de traitement des surfaces produisent des eaux usées chargées de polluants potentiellement toxiques comme des métaux et des solvants organiques ainsi que des acides qui, s'ils sont rejetés dans les réseaux d'égouts municipaux, peuvent corroder les canalisations et endommager les installations d'épuration. La manipulation et l'élimination des boues résiduaires ainsi que les sources et l'épuration des émissions atmosphériques constituent deux autres sujets de préoccupation. Le présent rapport expose les résultats d'une enquête nationale, réalisée en 1983-1984, sur:

1) les procédés de traitement des surfaces;
2) la production et le traitement des déchets solides, liquides et gazeux;
3) les règlements et leur application aux paliers fédéral, provincial et municipal.

Le principal objectif était d'identifier les problèmes environnementaux potentiels et de recommander des mesures préventives ou correctives.

Il existe 644 usines de traitement des surfaces au Canada; 539 d'entre eux ont rempli et retourné le questionnaire de l'enquête. Les réponses ont confirmé que la plupart des déchets liquides et solides produits par les ateliers sont dangereux. Pas plus de 60 p. 100 de ces déchets dangereux sont manipulés et éliminés comme tels. Des eaux usées non traitées, des bains épuisés et des boues résiduaires sont rejetés dans des égouts séparatifs ou directement dans des cours d'eau. L'élimination des déchets à l'extérieur semble régresser, et l'élimination sur place et(ou) le rejet à l'égout semblent augmenter.

Les lignes directrices fédérales sur les matières solides en suspension, le chrome, le cyanure, le cuivre, le plomb, le nickel et le zinc dans les effluents liquides provenant du traitement des surfaces métalliques, publiées en 1977, ne sont pas respectées dans une ou plusieurs province(s). Les règlements provinciaux et municipaux sont respectés seulement lorsqu'une surveillance régulière est exercée.

Il est recommandé, entre autres, que le gouvernement fédéral:

1) encourage l'emploi des techniques d'épuration et de récupération par des projets de démonstration;
2) détermine l'importance des émissions atmosphériques provenant des opérations de traitement de surface;
3) évalue les différents modes d'élimination, sur place et à l'extérieur, des déchets dangereux produits par les opérations de traitement de surface;
4) encourage les municipalités et les provinces à adopter et à faire appliquer des règlements antipollution spéciaux à l'intention de l'industrie;
5) prépare, en collaboration avec les autres paliers du gouvernement et l'industrie, du material didactique axé sur la protection de l'environnement destiné aux propriétaires, aux opérateurs de machinerie et aux ouvriers des ateliers, et qu'il en face la promotion.

TABLE OF CONTENTS

		Page
ABSTRACT		iii
LIST OF TABLES		vii
ACKNOWLEDGEMENTS		viii
1	INTRODUCTION	1
1.1	Objectives	1
1.2	Methodology	2
1.3	Status of Industry	3
1.3.1	Automobile Parts	4
1.3.2	Steel Strip Mills	5
1.3.3	Hardware	7
1.3.4	Electrical Appliances	7
1.3.5	Wire Goods	7
1.3.6	Plumbing Fixtures	7
1.3.7	Electrical Equipment	7
1.3.8	Furniture	7
1.3.9	Pole Hardware and Heavy Steel	8
1.3.10	Electronics	8
1.3.11	Engine and Worn Parts	8
1.3.12	Hollowware and Flatware	9
1.3.13	Jewellery	9
1.4	Industry Trends	9
1.4.1	Production Rates	9
1.4.2	Turnover Rate	11
1.4.3	Markets/Products	11
1.4.4	Finishing Processes	12
2	DESCRIPTION OF THE INDUSTRY	14
2.1	Mechanical Processes	14
2.1.1	Sandblasting	14
2.1.2	Grinding	14
2.1.3	Barrel Finishing	14
2.1.4	Polishing and Buffing	14
2.2	Chemical Processes	14
2.2.1	Solvent Cleaning	14
2.2.2	Alkaline Cleaning	16
2.2.3	Acid Pickling/Etching/Bright Dipping	16
2.2.4	Salt Bath Pot Cleaning	17
2.2.5	Quenching/Cyaniding	17
2.2.6	Chemical Conversion Coating	18
2.2.7	Electroless and Immersion Plating	19
2.3	Physical Processes	19
2.3.1	Plastic and Paint Coatings	19
2.3.2	Hot Dip Coating	21

		Page
2.4	Electrolytic Processes	21
2.4.1	Electrocleaning	21
2.4.2	Electropolishing	21
2.4.3	Anodizing	23
2.4.4	Electroplating	23
2.5	Waste Stream Generation and Characteristics	27
2.5.1	Wastewaters	27
2.5.2	Hazardous Wastes and Sludges	28
2.5.3	Air Emissions	30
2.6	Wastewater Treatment Technologies	31
2.6.1	Water Conservation	31
2.6.2	Effluent Treatment	31
2.7	Control of Air Emissions	38
2.8	Hazardous Waste Disposal	41
3	REGULATORY CONTROL	43
3.1	Federal	43
3.2	Provincial	44
3.2.1	Atlantic Provinces	44
3.2.2	Quebec	44
3.2.3	Ontario	45
3.2.4	Manitoba and Saskatchewan	47
3.2.5	Alberta	47
3.2.6	British Columbia	47
3.3	Municipal	48
3.4	Monitoring and Enforcement	48
4	RESULTS OF THE 1983-84 SURVEY	50
4.1	General Data	50
4.2	Pollution Control Practices	51
4.2.1	Wastewaters	52
4.2.2	Hazardous Wastes	53
4.2.3	Air Emissions	54
4.2.4	Recovery/Recycling	54
4.3	Future Surveys	54
5	SUMMARY AND RECOMMENDATIONS	55
5.1	Summary	55
5.2	Recommendations	56
REFERENCES		57
APPENDIX A	CHEMICALS USED IN SURFACE FINISHING THAT ARE INCLUDED ON THE U.S. EPA LIST OF PRIORITY POLLUTANTS	61
APPENDIX B	QUESTIONNAIRE USED IN THE SURVEY	65

		Page
APPENDIX C	CHEMICAL SUPPLIERS CONTACTED	81
APPENDIX D	TABULATION OF 1983-84 RESULTS	85
APPENDIX E	TABULATION OF 1973 RESULTS	107

LIST OF TABLES

Table		Page
1	SURVEY RESPONSE	3
2	SURFACE FINISHING MARKET BREAKDOWN	4
3	ELECTROLESS AND IMMERSION PLATING BATHS	20
4	ELECTROPLATING BATHS	24
5	WASTE GENERATION AND CHARACTERISTICS	28
6	HAZARDOUS WASTES GENERATED BY SURFACE FINISHING	29
7	SUMMARY OF EFFLUENT TREATMENT OPTIONS	33
8	FEDERAL METAL FINISHING LIQUID EFFLUENT GUIDELINES FOR DIRECT DISCHARGES	43
9	QUEBEC DRAFT REGULATIONS FOR DISCHARGE TO SANITARY SEWER	45
10	QUEBEC DRAFT REGULATIONS FOR STORM SEWER OR DIRECT DISCHARGES	45
11	ONTARIO MODEL MUNICIPAL SANITARY SEWER-USE BY-LAW LIMITS	46
12	ONTARIO MODEL MUNICIPAL STORM SEWER-USE BY-LAW LIMITS	46
13	ONTARIO AMBIENT AIR QUALITY CRITERIA REGULATIONS	47
14	BRITISH COLUMBIA EFFLUENT QUALITY OBJECTIVES FOR CHEMICAL INDUSTRIES - DISCHARGE TO MARINE OR FRESH WATERS	48

LIST OF PHOTOGRAPHS

		Page
1	BUMPER PLATING	6
2	FINISHED HINGES	6
3	SANDBLASTING	15
4	POLISHING	15
5	"CAGE" USED IN PHOSPHATING SMALL PARTS	18
6	MANUAL SPRAY PAINTING	22
7	MECHANICAL SPRAY PAINTING	22
8	BUMPER PLATING LINE	27
9	SPRAY RINSING CONSERVES WATER	32
10	DELAY OVER RINSE TANK REDUCES DRAGOUT	32
11	WASTEWATER CLARIFIER	36
12	PRESSURE FILTERS	36
13	VAPOUR COLLECTION OVER CLEANING TANKS	40
14	VENTILATION FOR PARTICULATE CONTROL	40
15	DEWATERED SLUDGE	41

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1 INTRODUCTION

In 1973, a survey of the Canadian metal finishing industry was conducted and the results were presented in the "Review of the Canadian Metal Finishing Industry" (1). This review discussed metal finishing processes, waste production, waste reduction and treatment practices of the industry. Its purpose was to provide the basis for subsequent effluent control requirements.

The "Metal Finishing Liquid Effluent Guidelines" (2), established in 1977, are national requirements intended to limit the pollutants discharged by metal finishers to water courses. They require metal finishers to follow good housekeeping practices in addition to using the best practicable technology for effluent treatment.

The metal finishing industry is known to discharge many potentially toxic chemicals. Appendix A lists chemicals that have been identified by the U.S. Environmental Protection Agency as "priority" pollutants (3).

The purpose of this report is to compare the current status of the industry with the findings presented in the previous review, and to measure the impact of the guidelines and other control requirements adopted by provincial and municipal agencies. This review has been expanded to include plating on non-conductors. In addition to liquid effluents, sludges and air emissions are examined.

1.1 Objectives

The specific objectives of this assessment were to:

a) describe plating processes that generate wastes and the appropriate control technologies;
b) determine the status of compliance with government controls; and,
c) recommend future actions that environmental agencies should consider.

The first objective includes brief descriptions of the common surface finishing processes and types of waste generated. Treatment, handling and disposal technologies for solids, liquids and air emissions are also reviewed. The focus is to determine: HOW is waste generated? WHAT are the characteristics of this waste? and WHERE does it go?

The second objective deals with municipal, provincial and federal legislation related to surface finishing operations. The enforcement of these controls and the resulting level of compliance are evaluated.

Finally, attempts have been made to identify potential environmental problems and concerns, and actions that may be taken to resolve these problems.

1.2 Methodology

A survey of Canadian surface finishing operations was conducted in 1983-84. The major surface finishing operations addressed in the survey were:

a) pretreatment (cleaning)
b) electroplating
c) electroless plating
d) anodizing
e) chromating (conversion coating)
f) cyanide hardening
g) quenching

Plants with only painting operations were excluded.

An initial list of all surface finishing companies was compiled, and a questionnaire was developed. The questionnaire used to establish the data base is shown in Appendix B.

Municipalities were contacted for any information about the industries they might have had but the bulk of the data were gathered by the distribution of the questionnaire directly to the industry. Data collection was carried out by Environment Canada regional staff either through plant visits and interviews, or through questionnaires mailed out and subsequently followed up by telephone. The questionnaire mail-out package contained an explanatory covering letter and a copy of the Wastewater newsletter, No. 16,* which describes water pollution control programs for the metal finishing industry. Data collection was completed March 30, 1984.

In Ontario and British Columbia a large number of responses were obtained by telephone follow-up a few weeks after mailing out the questionnaires. There were some cases of surface finishers refusing to participate. However, cooperation from the industry was generally very good as 78% of the questionnaires were returned. Table 1 is a summary of the survey response.

The plant visit and interview approach was successful in Nova Scotia, New Brunswick and Alberta. In Alberta, a limited number of plants were visited. After the interviews, all pertinent information was transferred onto questionnaires.

---

* Environment Canada, September 1982.

TABLE 1 SURVEY RESPONSE

Province	Questionnaires Mailed	Replies Received	Replies Applicable	Surface Finishers Not Contacted/ Not Responding
Nova Scotia	11	11	10	-
New Brunswick	7	7	7	-
Quebec	174	174	128	-
Ontario	1364	961	296	65
Manitoba	32	32	27	-
Saskatchewan	-	1	1	5
Alberta	12	8	8	25
British Columbia	376	332	62	10
CANADA	1976	1526	539	105

Manitoba and Quebec District and Regional Offices were able to supply existing information about surface finishers in their provinces in lieu of the mailout. This was not as detailed as the information obtained by questionnaire.

The questionnaires were reviewed prior to data analysis to improve their clarity. Although in 1973 the survey chemical consumption data collected was multiplied by a correction factor to allow for companies that did not respond, no correction factors were used on the 1983 data. All the data presented is as it was received.

Companies with only painting operations were not included in the survey. Companies with chemical, mechanical and coating operations only were included because these operations often produce metal-containing wastes.

In Ontario and British Columbia significantly more companies were mailed questionnaires than during the 1973 survey, which probably accounts in part for the higher number of applicable responses. In addition, 22% of companies that responded to this question, or 14% of all responses, started operation in the last ten years. The large increase in the reported number of surface finishers in Quebec is likely due to the inventory activities of the Montreal Urban Community, Quebec Ministry of Environment and Environment Canada.

1.3 Status of Industry

Surface finishing consists of various chemical and physical processes which change the surface of a product to enhance its appearance (decorative), increase its corrosion resistance, or produce surface characteristics essential for subsequent

operations (functional). The most prevalent surface finishing processes are electroplating, anodizing and hot dip galvanizing. These and other processes are discussed in detail in Section 2.

Surface finishing companies can be divided into two basic categories, namely job (contract) and captive shops. Job shops provide services to a wide range of customers and normally specialize in one or several types of surface finishing. Captive shops, on the other hand, as the name implies, serve only one client and are often integrated with large manufacturing operations or are parts of a manufacturing process line.

Surface finishing is a key process in many manufacturing operations since it may have such a profound effect on the appearance and functioning of the final product. Table 2 lists these manufacturing industries and a breakdown of the surface finishing market.

TABLE 2 SURFACE FINISHING MARKET BREAKDOWN

	% percent of market ($ Cdn 1983)
Automobile parts	26.0
Steel strip mills	14.0
Hardware	12.0
Electrical appliances	10.0
Wire goods	10.0
Plumbing fixtures	6.0
Electrical equipment	5.0
Furniture	5.0
Pole hardware & heavy steel	5.0
Electronics	4.0
Engine & worn parts	2.0
Hollowware & flatware	0.5
Jewellery	0.5

1.3.1 Automobile Parts. In recent years the use of electroplated metals for decoration in the automobile industry has fallen drastically. The reasons for this change are a trend towards smaller cars and a designer preference for materials other than nickel and chromeplating.

The parts of an automobile normally plated are as follows:

a) bumpers,

b) lamp bezels,

c) door handles and window regulators,

d) dashboard knobs,

e) grills,

f) locks, hinges, fasteners, fittings and other miscellaneous parts.

Bumper manufacturers are the major clients for decorative surface finishing services. Although the trend to soft plastic coating and paint finishing on bumpers has reduced this market, the demand in the United States for this plating service is larger than present capacity. Therefore Canadian job shops currently do a large percentage of automotive finishing for U.S. customers. This practice is expected to continue, creating an overall increase in nickel and chrome plating of about 10 percent per year for the next two or three years.

Bumper recycling is another market served by surface finishers that is quite separate from the automotive manufacturing component. This service is provided by job shops and the market depends on the usage of nickel and chrome on bumpers by automotive producers.

Lamp bezels are still being electroplated but there is a definite trend to the use of plastic (plated and unplated) and anodized aluminum.

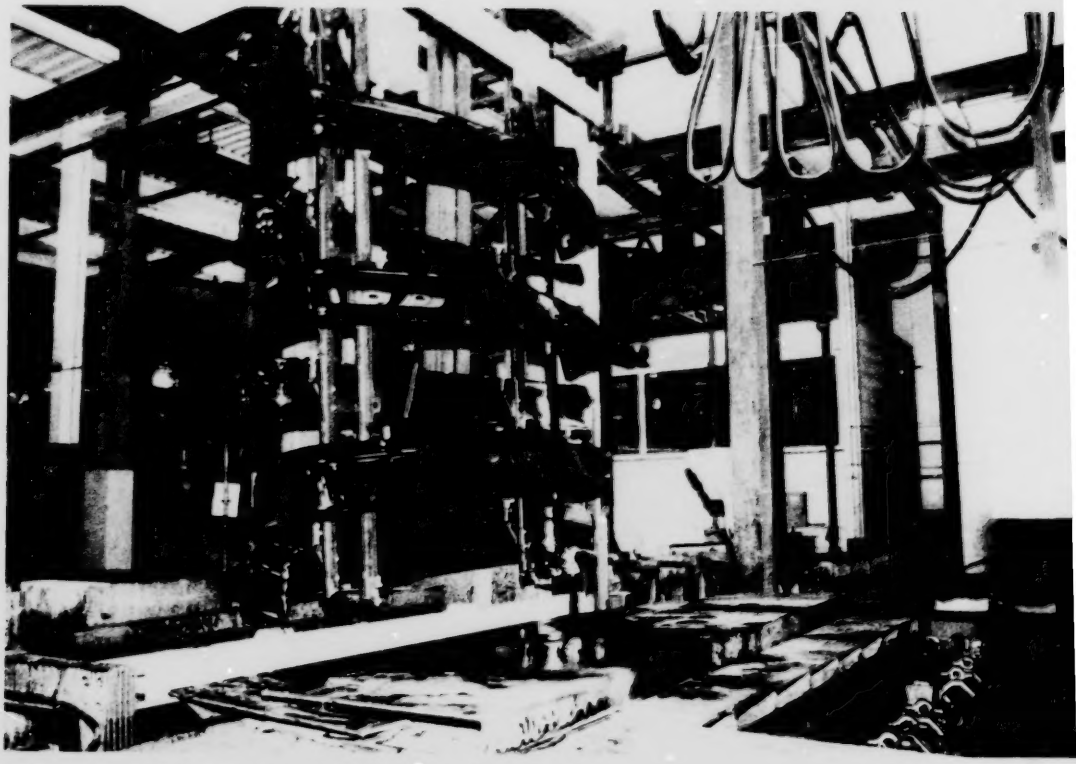
Door handles and regulators are usually nickel and chrome plated. This work is normally contracted out by the automobile manufacturing companies.

Dashboard knobs are primarily made of plastic and have a nickel-chrome surface finish.

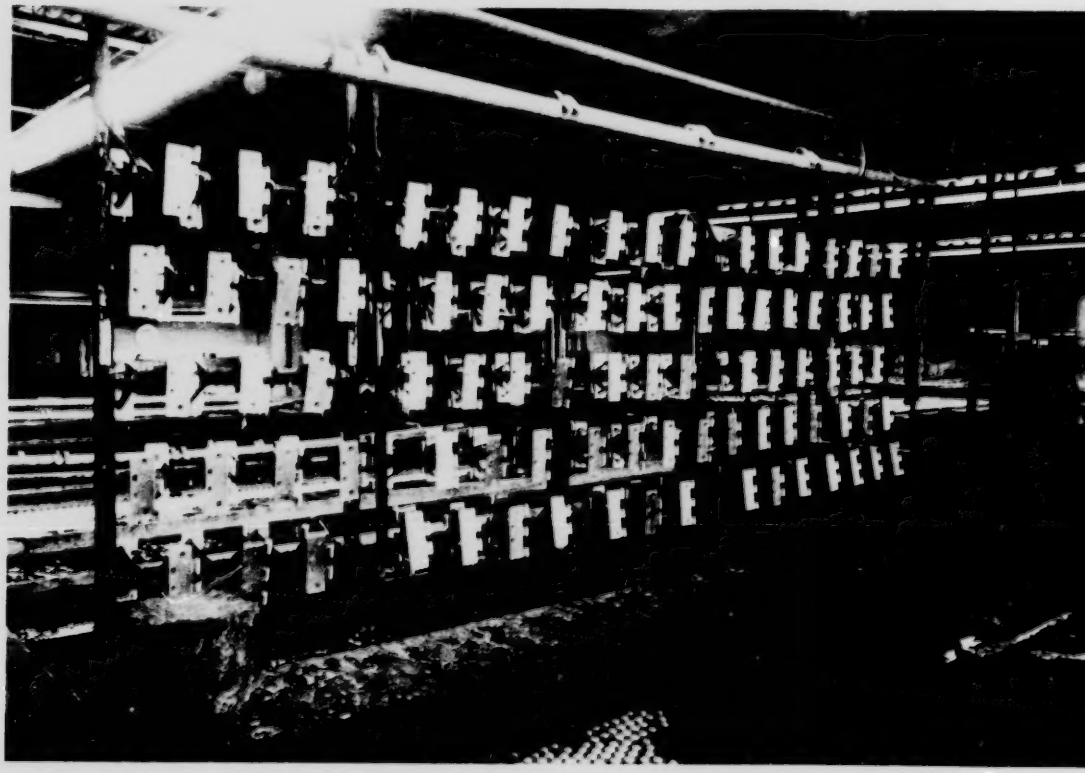
Grills are fabricated from plastic and in some cases plated. The requirement for surface finishing will remain proportionately constant to vehicle sales.

Locks, hinges, fasteners, fittings and miscellaneous parts are treated for corrosion protection. Demand for functional finishes has increased with pressure to reduce corrosion and to extend the life of vehicles. Zinc plating, phosphate coatings, conversion coatings, rust resistant oils and paint are used for this purpose. Demand in this area has more than doubled since 1973 and will continue to grow at about 10 to 20% per year as usage extends to more automobile parts, including bumpers.

1.3.2 Steel Strip Mills. Cold rolled steel in strip form is plated either with zinc or tin. The zinc plated strip is used in the fabrication of parts that require added corrosion protection on interior surfaces. The plating is done in a zinc sulphate solution. Zinc can be plated on both surfaces before the steel is formed. In this way, a zinc coating can be achieved on interior surfaces that would otherwise be impossible to plate. Tin strip



Photograph 1. Bumper Plating



Photograph 2. Finished Hinges

plating is performed in a stannous sulphate solution. These strips are used primarily in can manufacturing. However, aluminum is replacing tin-plated cans in a number of areas and, if Ontario legislation is changed to permit the use of aluminum, the demand for tin-plated strip could almost cease to exist.

1.3.3 Hardware. Tools, door locks and building hardware are included in this group. The types of surface finishes required are nickel-chrome, zinc, brass and bronze. The demand for hardware products comes directly from the housing and construction industry and the quantity of surface finishing required fluctuates accordingly. Substitution of materials, such as plastics for metal, and changes in technology have not been significant in this industry and are not envisaged over the next 10 years.

1.3.4 Electrical Appliances. The major appliance industry, including manufacturers of stoves and refrigerators, has a constant requirement for surface finishing, primarily decorative plating on handles and trim. Changes in demand since 1973 have been closely related to production rates in the housing and construction industries. The small appliance industry, which includes the manufacture of toasters, ovens, coffee pots and tea kettles, has shown a reduced requirement for nickel-chrome finishes because of the shift to plastic exteriors (plated and unplated). No increase in the surface finishing demand is expected from this industry.

1.3.5 Wire Goods. These products include display racks, shelving and shopping carts. The typical surface finish is electroplated nickel, chrome and brass. Applications for wire goods are numerous and growth potential is in the order of five to eight percent per year. Plastics have intruded into this market but the effects have not been significant so far.

1.3.6 Plumbing Fixtures. These products include taps, and bathroom and kitchen fixtures. Base metals are either zinc or chrome plated. The trend since 1973 has been toward the use of nickel- and chrome-plated plastics. Demand is related to the housing and construction industries.

1.3.7 Electrical Equipment. Products included in this group are service boxes, conduit pipe and transformer parts. Three surface finishes, zinc and tin electroplate and hot dip galvanizing, are used. Surface finishing production rates for these goods have fluctuated since 1973 with the housing and construction industries and are expected to continue to do so.

1.3.8 Furniture. Steel furniture is usually plated with nickel and chrome, nickel and brass, or brass only, painted, or both. Growth in this area is highly variable and difficult

to predict as it depends on regional trends and designer preferences. For example, demand in Montreal is quite different than in Toronto. There has, however, been a fairly consistent demand in the U.S. and exports of these products have been considerable. Long-term growth of demand for these products has been low and no significant change is predicted in the future. About five percent of the surface finishing market will continue to be generated by these products and the work will likely be carried out primarily in job plating facilities.

1.3.9 Pole Hardware and Heavy Steel. Products such as highway guard rails, transmission towers and some heavy steel structures used in construction are included here. Hot dip galvanizing is used since the parts are too large to electroplate. Effective corrosion protection is a primary factor as the parts generally have to withstand outside conditions for long periods. The thick deposits of zinc required to meet these corrosion standards can be applied more economically with hot dip galvanizing.

1.3.10 Electronics. The production of printed circuit boards requires primarily copper plating but nickel, gold, tin and tin-lead (solder) processes are also used. Printed circuit boards are the foundation of electronic machines ranging from telecommunications systems to computers and robots. The technology has evolved from primitive wire boards to the current sophisticated micro-circuit boards, tending towards diminishing size and increasing complexity. The new generation of boards are multi-layered, resulting in a substantial reduction in the actual area plated per component. Offsetting this reduction in the area plated is the increasing demand for these products.

Because of the controlled nature of most printed circuit board manufacturing operations, effluent quality is quite predictable. In addition, rapid changes in technology are occurring and processes are regularly updated. These factors have lead to several unique developments in this industrial sector. Many plants have made substantial reductions in water use through counterflow rinsing and mechanized control of production lines. Waste discharges are being shipped to recycling centres to recover copper crystals and solute.

While production rates for printed circuit boards are expected to increase over the next 10 years, the reduction in the surface areas actually plated, the modern state of the industry and the trend to reduced water usage and metal recovery suggest that pollutant generation rates from this industry will not increase.

1.3.11 Engine and Worn Parts. Parts requiring surface finishing come from pumps, diesel engines, gasoline engines, paper mill rolls, and so on. The parts vary in size and

require heavy deposits of chromium to restore the original dimensions and to provide a durable surface coating. The process used is referred to as hard chrome plating.

The oil, pulp and paper, transportation and forestry industries are the primary sources of demand. Since these industries are distributed across the country, hard chrome plating installations are found in most provinces. The oil industry has created an increasing need in Alberta. Similar demand is now being created in the Maritimes with the new offshore drilling operations.

Electroless nickel plating and conventional hard chrome plating are being used for some of these applications.

1.3.12 Hollowware and Flatware. Hollowware products include coffee pots, tea pots, ice bowls, cream and sugar pots, gravy boats and flower holders. These products are often plated with silver using a silver cyanide plating bath. There is little or no growth expected in this market; competition from West Germany and Japan has significantly affected Canadian production.

Flatware includes tableware such as knives, forks and spoons. These products are made either from stainless steel or from cold-rolled steel which is plated in a silver cyanide solution. Flatware manufacturing in Canada has been affected by the same foreign market competition as hollowware. As a result this industry has declined since 1973 and is expected to show little or no growth in the near future. Demand for the product is primarily dependent on the population growth and on the formation of new households.

1.3.13 Jewellery. All costume jewellery falls under this heading. The typical surface finish is a flash coating of precious metal such as gold or rhodium on a nickel base. Annual growth is expected to be about one to three percent.

1.4 Industry Trends

1.4.1 Production Rates. In order to make comparisons between the results of the 1973 and 1983 surveys of the surface finishing industry, an understanding of the overall status of the industry over the years is required. A number of approaches were used in this assessment. Some of the questions asked in 1973 and 1983 provide an indication of the production rates and capacity of the industry. In addition, contacts were made with suppliers to the industry for a general understanding of trends in sales of raw materials. A list of the individuals contacted is included as Appendix C. Finally, Statistics Canada manufacturing census reports were reviewed. The information from these sources

combined with personal knowledge of the industry were used to reach the conclusions in this section.

A number of discrepancies among the sources became immediately obvious. For example, there are only two major suppliers of nickel, Inco Ltd. and Falconbridge Limited. They reported total annual consumption of nickel in the surface finishing industry in both 1973 and 1981 to be about 3630 tonnes. The 1973 survey reported total annual consumption to be about 1460 tonnes, while Statistics Canada reported 810 and 944 tonnes in 1973 and 1981, respectively.

Some of the discrepancies in the data can be explained. The 1983 survey of the industry included 539 companies. Statistics Canada listed only 243 in its 1981 manufacturing census. Statistics Canada did not survey captive plants which are part of larger manufacturing operations. This may partly account for the lower number of firms surveyed. In the 1973 survey, approximately 341 metal finishers responded; the number did not include all operating plants. These omissions do partially account for the discrepancies in reported consumption, but part of the variation cannot be explained. Based on personal knowledge of the industry and the potential sources of error, suppliers' figures for production and consumption, where available, are considered more accurate than survey results.

The surface finishing industry grew approximately two to three percent between 1973 and 1981 and showed negative growth from 1981 to 1984, with a net reduction of three to five percent. Forecasts suggest that growth will be limited or negative over the next 10 years. Functional finishes will become increasingly more prevalent; if any growth does occur it will be in this area.

Nickel consumption remained fairly constant between 1973 and 1981 at about 3630 tonnes per year. Consumption dropped in 1982 and 1983 to about 2270 tonnes and is expected to stabilize at about 2040 tonnes annually over the next ten years. This reduction of 44 percent over 1981 levels reflects an overall expectation of lower economic activity and a substantial reduction in the demand for decorative finishes.

Estimating the quantities of zinc consumed by the industry is more difficult because of the greater number of suppliers. The figures obtained indicate an increase in zinc usage of about eight percent from 1973 to 1983. This corresponds to the increased demand for functional finishes. Demand for hot dip galvanizing generally parallels that of zinc-plated finishes as both are used in the automotive and construction industries. Production rates are projected to continue to increase at about two to three percent per year in this sector over the next ten years.

The use of chromates, phosphate and rust inhibiting organic materials is expected to increase with zinc usage. These chemicals may be applied alone or with other finishes.

1.4.2 Turnover Rate. The number of new companies coming into an industry and the number leaving are important from an environmental control perspective for several reasons. First, industries with high turnover rates require constant updating to maintain current files of operating companies. This is particularly true where site-specific monitoring or analysis is anticipated. Secondly, high turnover provides the potential for new technology to be adopted with relative ease and minimal losses in production.

Turnover rates are fairly high in this industry; 75 of the 539 plants surveyed reported that their operations were less than ten years old. The number of plants going out of operation was nearly the same, resulting in only a small increase in the overall number of establishments. In general, both large and small plants have gone out of business but most of the new plants are smaller so that the total capacity of the industry has been reduced.

Between 1973 and 1981, a major adjustment in the industry occurred due to substantial reductions in demand for surface finished products in the automotive industry. The decrease in electroplating of zinc base die castings and steel bumpers lead to a number of plant closures. Because many of the plants in the U.S. had large capacities and operated on the basis of high volume runs, they were more severely affected than the smaller Canadian plants. The remaining five or six automotive finishing plants in Canada are now serving virtually all of the North American demand for nickel plating of bumpers and zinc die castings.

1.4.3 Markets/Products. New markets for surface finished products will be related to functional applications. As rust resistance guarantees in the automotive industry become more difficult to meet, the demand for surface treatments for corrosion protection has increased. Hot dip galvanizing and electroplated zinc will experience increased demand but these applications will be challenged by other finishes such as conversion coatings based on organic oils and resins.

The use of electroplated plastics in the automotive industry expanded considerably after 1973 but has now stabilized. The demand for these finishes is being met by three or four establishments in Canada. In the plumbing industry electroplated plastic fixtures are finding wider application; growth will be related to that in the construction industry.

A major new market for electroplated plastics has been created by the demand for printed circuit boards. Between 1973 and 1983 demand for this product increased over three-fold. Despite these remarkable increases, the quantity of plastic being surface finished is small compared to production quantities associated with the construction and automotive industries. The demand for printed circuit boards is expected to continue to increase over the next five years by 5 percent.

Foreign competition has increased during the last five years and is expected to persist or increase over the next ten years. It is expected that Canadian surface finishers may be able to maintain their current production rates but their ability to increase their market share is uncertain.

1.4.4 Finishing Processes. Two primary factors are directing research and development in the surface finishing industry. First, as more stringent environmental regulations are enacted and enforced the industry is faced with further reducing and treating its wastes. The second factor is the shift to functional finishes and more corrosion-resistant coatings. This demand is coming mainly from the automotive industry. In response to this pressure new plating baths and coating formulations are being developed. Some have already received commercial acceptance.

Research on zinc plating baths has concentrated on the elimination of cyanide. Most recent developments have been with the zinc chloride process. Zinc sulphate and alkaline zinc processes have also been developed for special applications and are finding wider usage.

Trivalent chromium plating has been widely adopted in the U.S.A. and is gradually being introduced in Canada. The trivalent form of chromium has not been found to be carcinogenic or mutagenic like the hexavalent form and is more easily precipitated out of solution. Because this process consumes fewer chemicals it also results in less sludge. Some technical aspects of the finish are superior but there is a noticeable difference in colour between hexavalent and trivalent chromium coatings. Finally, there is a moderate capital cost to switch processes, although operating costs are lower with trivalent chromium.

Alloy plating is an area that shows promise and is receiving considerable attention. These processes use combinations of metals, for example, zinc-copper (brass), tin-lead (solder) and zinc-nickel, for the plating process. By using combinations of metals, expensive elements can be partially replaced by less expensive ones, reducing overall production costs. Secondly, the alloys are often more corrosion-resistant than either of

the metals alone. From an environmental perspective, some improvements in waste characteristics can be achieved when less toxic metals are substituted.

Conversion coatings are receiving greater attention for application to electroplated or hot dipped zinc finishes. Combinations of various coatings and new mixtures are being examined for corrosion protection capabilities. Many of the new coatings are derived from organic compounds.

Finally, new base metals are being substituted in some products. For example, General Motors Company started using magnesium for grill assemblies on its Fiero model in 1984. The light weight of the metal was a major factor in its selection. Currently, an anodizing process is used to treat the magnesium with a black coating but undoubtedly new finishes will be developed to meet consumer preferences.

2 DESCRIPTION OF THE INDUSTRY

2.1 Mechanical Processes

2.1.1 Sandblasting. Metal parts are frequently cleaned and given a smoother surface finish by sandblasting. Aluminium oxide and silicon carbide, rather than sand, are usually used as abrasives in dry blasting the workpiece. In wet blasting a slurry is applied consisting of the abrasive, wetting agents, rust inhibitors and anti-settling agents. The process abrasive must be disposed as solid waste when significant impurities accumulate. The rinse waters following sandblasting may contain some abrasive, metal scale and oils.

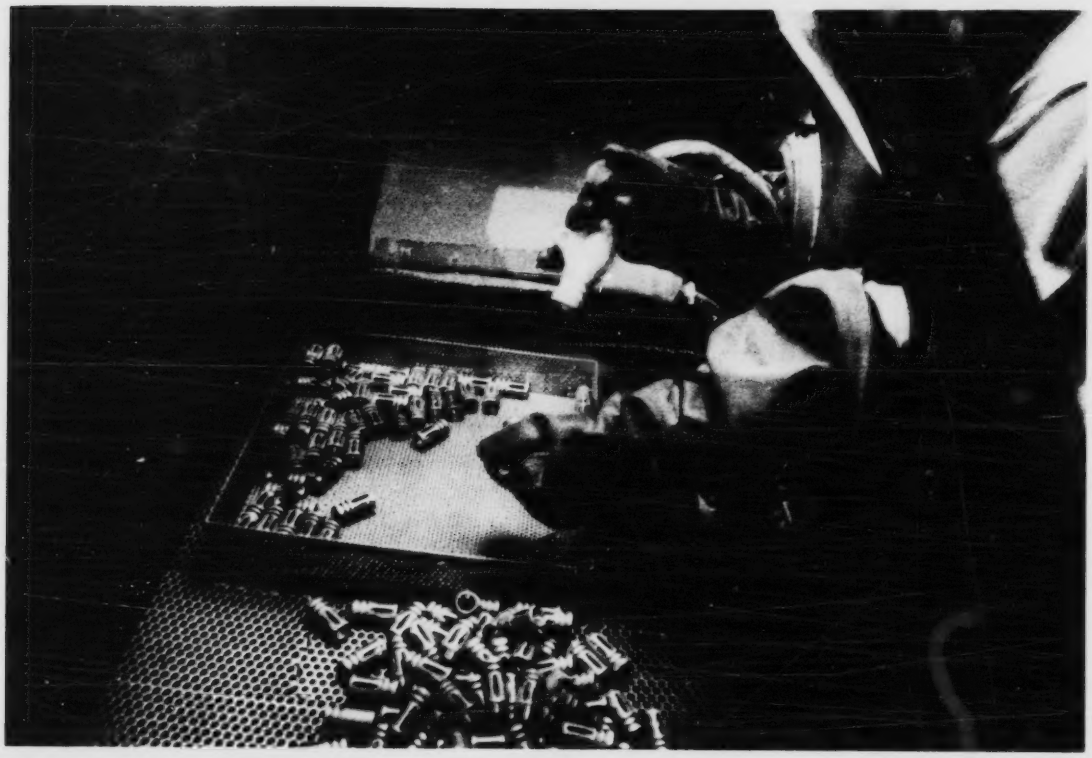
2.1.2 Grinding. Grinding operations require the use of lubricating oils, wetting agents, rust inhibitors and other additives applied to an abrasive wheel or belt. An oily sludge containing ground metal is collected for disposal. Although no wastewater is generated during grinding, oil, grit and metals may add to solid or liquid waste streams.

2.1.3 Barrel Finishing. Barrel finishing, or tumbling, is used to clean, deburr and polish metal, ceramic or plastic substrate. The workpieces are loaded into a rotating barrel with added abrasives and one or more additives such as alkaline cleaners, anti-rust agents, acids and oils. A variation of the rotating operation is vibratory finishing, during which the load may simply be oscillated or may undergo both actions simultaneously. The parts are subsequently rinsed; oils, chemical additives, grit, common metals, and cyanide may enter the effluent stream. The process solution is generally discharged on completion of each production run.

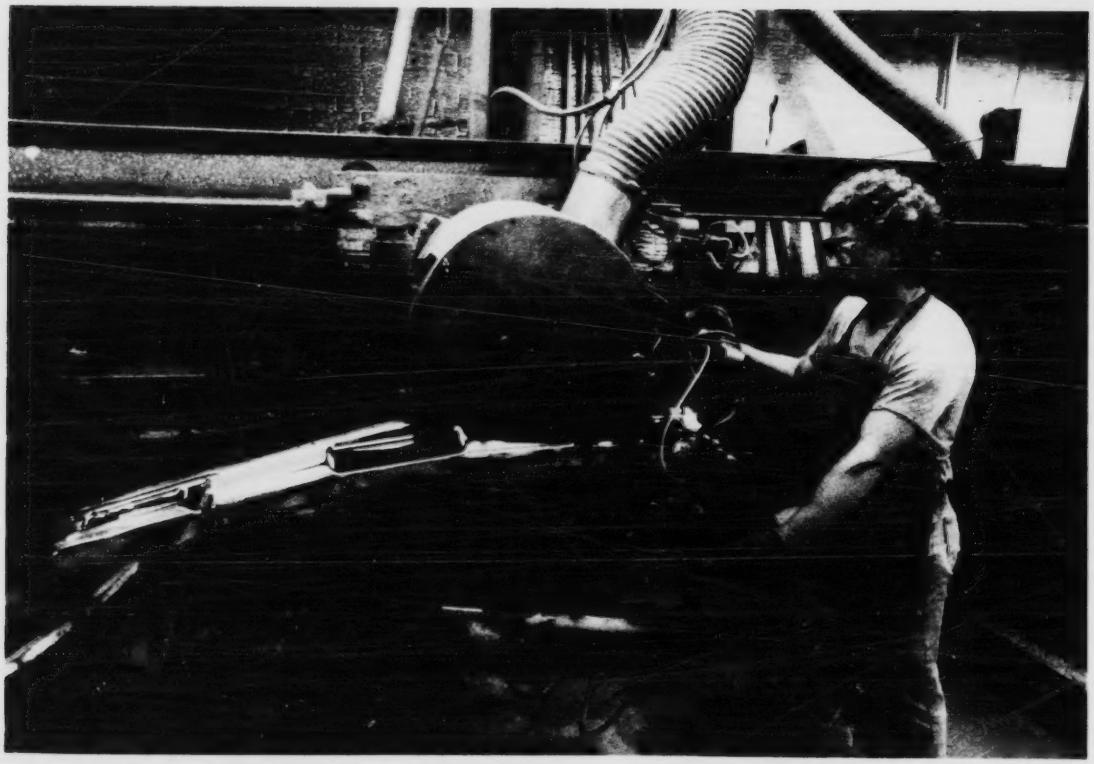
2.1.4 Polishing and Buffing. Polishing and buffing involves the application of an abrasive material to a rotating wheel which contacts the workpiece. Greases, oils, soaps and other compounds are used in the process. Along with fine metallic grit, these compounds enter wastewater or solid waste during area cleanup. Fine metal and abrasive dust is also released to the atmosphere in the work area and the outside environment unless containment equipment is installed.

2.2 Chemical Processes

2.2.1 Solvent Cleaning. Solvent cleaning is a widely used process to remove heavy surface oil and grease. Solvent is placed in a boiling chamber and escaping vapours rise above the liquid and are condensed on overhead cooling coils. The condensed liquid is returned to the boiling chamber to complete the continuous process. This procedure produces two cleaning mediums, i.e., a liquid phase and a vapour phase. In some cases,



Photograph 3. Sandblasting



Photograph 4. Polishing

parts are not immersed in the liquid because the condensed vapour is sufficient for cleaning. Some cleaning may be done simply through immersion of the workpiece in cold solvents.

Common solvents used for liquid and vapour cleaning are chlorinated hydrocarbons such as 1,1,1-trichlorethane, trichloroethylene, perchloroethylene and methyl chloride. Other solvents such as toluene, kerosene and alcohol receive limited use as liquid cleaners. Pure solvent may be separated from the oil and oily sludge build-up by distillation and reused. Smaller amounts of solvent, when spent, are often simply discarded to sewer. Irritating and hazardous solvent fumes may escape to the plant and outside atmosphere.

2.2.2 Alkaline Cleaning. Alkaline spray and soak cleaning are major sources of contaminated wastewater because of the frequency with which these operations are used in the finishing sequence. Many unit operations require a cleaning stage immediately before and/or after the operation.

Cleaners are water-soluble combinations of alkalis and chemical additives specific to the nature of the surface to be cleaned and soil to be removed. There are no less than 700 surface cleaning agents commercially available. As well, many additives are proprietary, making it difficult to categorize the ingredients of cleaning baths.

The cleaning solutions vary in alkalinity and accumulate saponified greases (soaps), emulsified greases, small amounts of base metals, complexed metal and solids. Baths are discharged when spent, and generate substantial quantities of sludge when treated. One or more rinses always follow cleaning and small amounts of cleaner end up in the wastewater. Attention should be given to open tanks that may release polluting mists and fumes.

2.2.3 Acid Pickling/Etching/Bright Dipping. Acid pickling removes any alkaline residue left from cleaning and any scale and rust. The most common acids used are hydrochloric, sulphuric, nitric, chromic and phosphoric. Acid concentrations may be up to 50 percent and, for some applications, the acid may be heated. Usually the workpiece is immersed briefly in the acid bath but recently some spray operations have been introduced. In spite of the use of chemical inhibitors, a significant amount of metal from the workpieces and the plating racks is dissolved causing these acid baths to have a short life before discharge is necessary. Rinse waters containing dragout from pickling baths contribute metals, acids, oils, wetting agents, detergent and additives to plant effluent.

Open acid tanks emit noxious and hazardous chemical fumes that require collection and treatment.

Etching baths are a combination of acids that dissolve the surface of a metal or plastic workpiece in a controlled manner, often to produce a specific design configuration and condition. This surface activation is also required in preparation for finishes such as the electroless plating of nickel or copper on printed circuit boards, and for improving coating adhesion, particularly on plastics. Many acids, including chromic acid, may be used in etching baths and contribute to waste production when discharged. Waste consists mainly of the dissolved materials (plastics or metals), spent acids and the rinse water associated with the etching process.

A related application is the stripping of defective electrodeposits by immersing the workpiece in an acid bath similar to an etching bath. Electrolytic stripping is used in some cases to accelerate the metal removal process.

Bright dipping is a process used to remove oxides and to prepare the surface of copper, copper alloys, aluminium and stainless steel for other finishes. The waste produced is similar to pickling and etching waste, consisting of a variety of spent acids, base metal and rinses.

2.2.4 Salt Bath Pot Cleaning. Molten baths of sodium hydroxide, sodium cyanide and other chemical additives are used to remove rust and scale from metal. Sludge is produced and batch discharges of the salt bath occur regularly. Rinse waters contain removed metal, cyanides and burned oil residues.

2.2.5 Quenching/Cyaniding. Quenching baths are either:

i) pure oil,
ii) oil with chemical additives,
iii) water-oil emulsions,
iv) brine solutions, or
v) water based solutions,

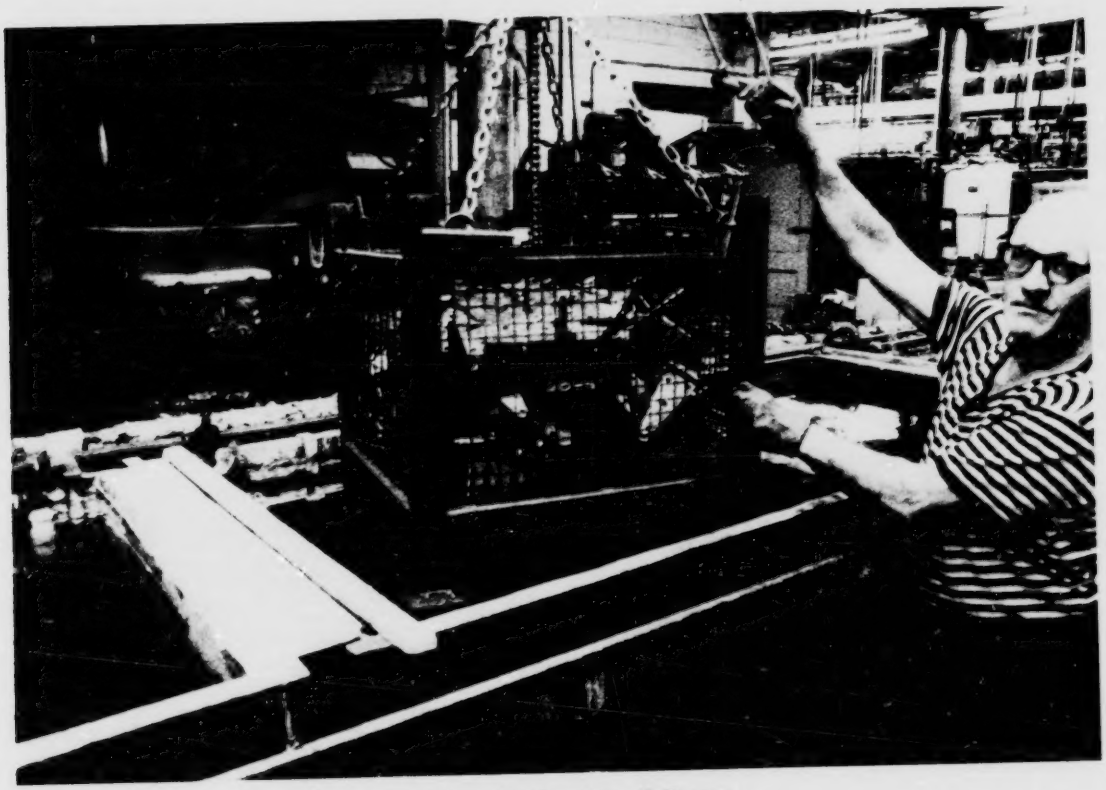
depending on the cooling characteristics desired.

Brine quenches may contain sodium chloride, calcium chloride, sodium hydroxide, sodium carbonate, hydrochloric or sulphuric acid. Water and water-based quenching and rinsing solutions may contain dissolved salts, soaps, alcohols, oils, emulsifiers and slime. Molten cyanide baths are used in heat treating and carbonitriding. These baths are usually composed of sodium cyanide and other inert salts.

Rinse water and quenching bath discharges contribute to liquid effluents. Spent baths include some reactive chemicals as well as any metal scale, oxide and oil from the workpieces. This waste may also form a sludge requiring periodic disposal.

2.2.6 Chemical Conversion Coating. Chromating produces, by means of a chemical reaction, a thin chromate coating on zinc, cadmium, aluminium, copper and brass that provides corrosion protection. Chromate coatings may also impart colour and luster and act as a base for paints. The contents of chromating baths are usually chromic acid, dichromate, and active organic or inorganic compounds. In these acidic baths, both hexavalent and trivalent chromium are used and may enter the waste stream either through rinse water or discharge of spent solutions.

Phosphating is a related process which provides steel or iron with a superior bonding surface for paints, waxes, oils and lubricants and also improves metal forming capabilities. Phosphates of zinc, iron, manganese and calcium in phosphoric acid make up the bath. Other metal salts and additives may also be present. Phosphate coatings are usually "sealed" by a mild chromic acid rinse.



Photograph 5. "Cage" Used in Phosphating Small Parts

Colouring baths, used to blacken phosphate conversion coatings, may contain copper, nickel, lead, iron, zinc or arsenic in a variety of solutions, the ingredients of which are invariably proprietary. This chemical process leaves a metal oxide layer of various shades that is highly resistant to heat and fading.

The waste produced from all chemical conversion coating operations comes from rinse waters and batch discharges of process baths.

2.2.7 Electroless and Immersion Plating. Electroless, or autocatalytic, plating is used to apply nickel, cobalt, palladium, platinum, copper, gold, silver and alloys of these metals onto another metal or plastic. The metal being deposited acts as the catalyst while it is being reduced from its ionic state in solution to form a deposit. Because the deposit is its own catalyst, coating thickness continues to increase with time at an even rate over the surface. Common applications of autocatalytic plating are plating nickel or copper on plastics, such as for printed circuit boards, or to provide a metal base on plastic to prepare it for electroplating. Plastic and other nonconductors must be pretreated by etching prior to electroless plating.

Immersion plating applies a metallic coating without an outside source of electric current. The metal in solution deposits on the workpiece by displacing the basis metal.

Some autocatalytic and immersion plating baths are listed in Table 3. The wastes generated during immersion and autocatalytic plating consist of rinsewater and process bath discharges. Immersion process baths contain metal salts, chromates, dissolved base metal, alkalis, and cyanide or ammonia complexing agents. Autocatalytic baths contain the coating metal, sodium hypophosphite, formaldehyde or other reducing agents and various complexing and chelating agents.

2.3 Physical Processes

2.3.1 Plastic and Paint Coatings. Plastic powder coatings are being used increasingly in a number of applications because of the ease of transporting the dry powder and the absence of any harmful solvents and odours. The plastic is electrostatically charged and sprayed onto the oppositely charged workpiece. The coating is then thermally fused in an oven and excess powder is recycled. The workpiece is initially prepared by any of the surface preparation and cleaning processes used prior to plating and is usually phosphated.

Industrial paint is applied in spraying booths or by dip coating. Mechanical surface finishing, cleaning or chemical conversion coating prepare the surface.

TABLE 3 ELECTROLESS AND IMMERSION PLATING BATHS

Electroless (Autocatalytic) Plating		
Nickel		nickel chloride nickel sulphate sodium hypophosphite sodium hydroxyacetate acetic acid lactic acid molybdic acid propionic acid
Copper		copper sulfate sodium potassium tartrate sodium hydroxide sodium carbonate formaldehyde versene-T
Gold		potassium gold cyanide potassium cyanide potassium hydroxide potassium borohydride
Silver		silver cyanide sodium cyanide sodium hydroxide dimethylamine borane thiourea
Immersion Plating		
Tin	on aluminium:	sodium stannate
	on copper:	tin chloride sodium cyanide sodium hydroxide
	on steel:	stannous sulfate sulphuric acid tin chloride
	on zinc:	tin chloride

Electrocoating is an electrolytic process used to deposit an organic material, such as paint. Direct current applied in an alkaline bath causes the migration of pigment particles towards the cathodic workpiece.

The wastewater from coating operations contains scrubbing and rinse waters, any solvents, pigments, resins, common metals and additives present in the coating, and built up impurities and solids. Waste plastic or paint form a sludge which is disposed separately. Volatile solvent fumes are a health and environmental hazard and must be contained.

2.3.2 Hot Dip Coating. Metal may be physically coated by dipping in a molten metal bath. An alloy of the two metals is formed at the contacting surface and binds the metal coating to the substrate. Precleaning and a flux dip are often required to prepare the metal surface for dipping. Quenching often follows hot dip coating. Aluminium, lead and tin are sometimes applied in this process for decorative and protective functions. However, hot zinc coating, also called galvanizing, has many industrial applications and is the most commonly used. A major use is the galvanizing of steel strip to impart corrosion resistance.

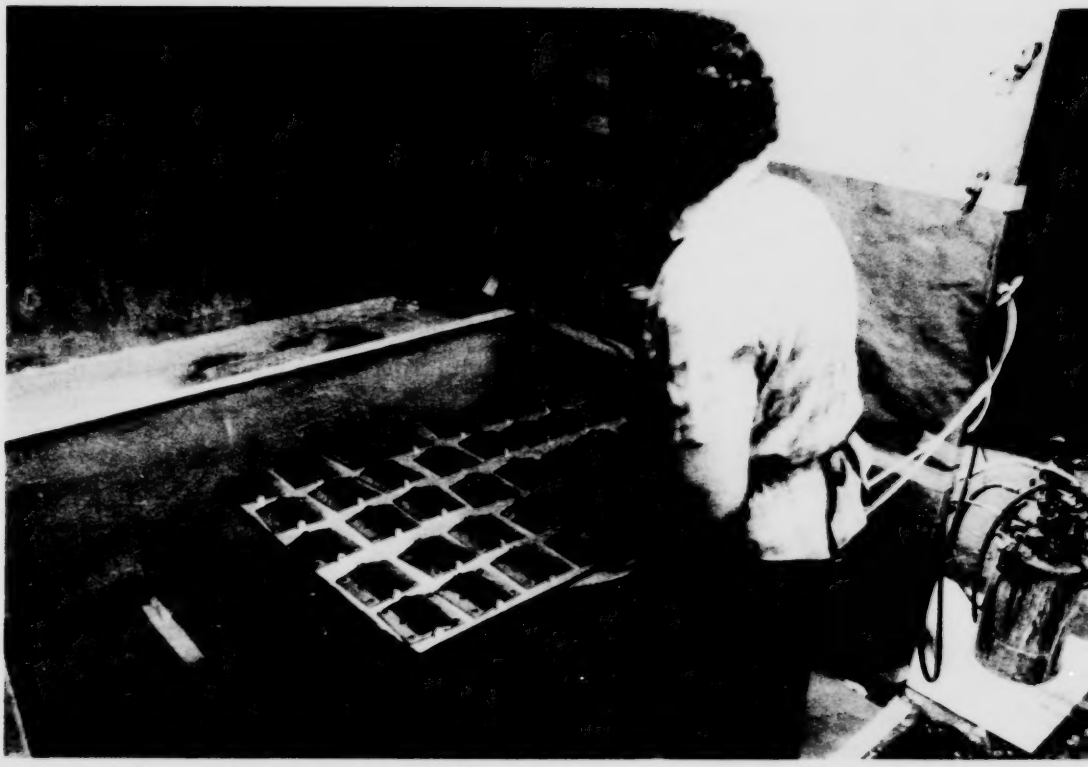
No waste is generated during the actual hot dip coating operation but rinse waters from precleaning and quenching may contribute common metals to effluent with problems and quantities similar to electroplating operations.

2.4 Electrolytic Processes

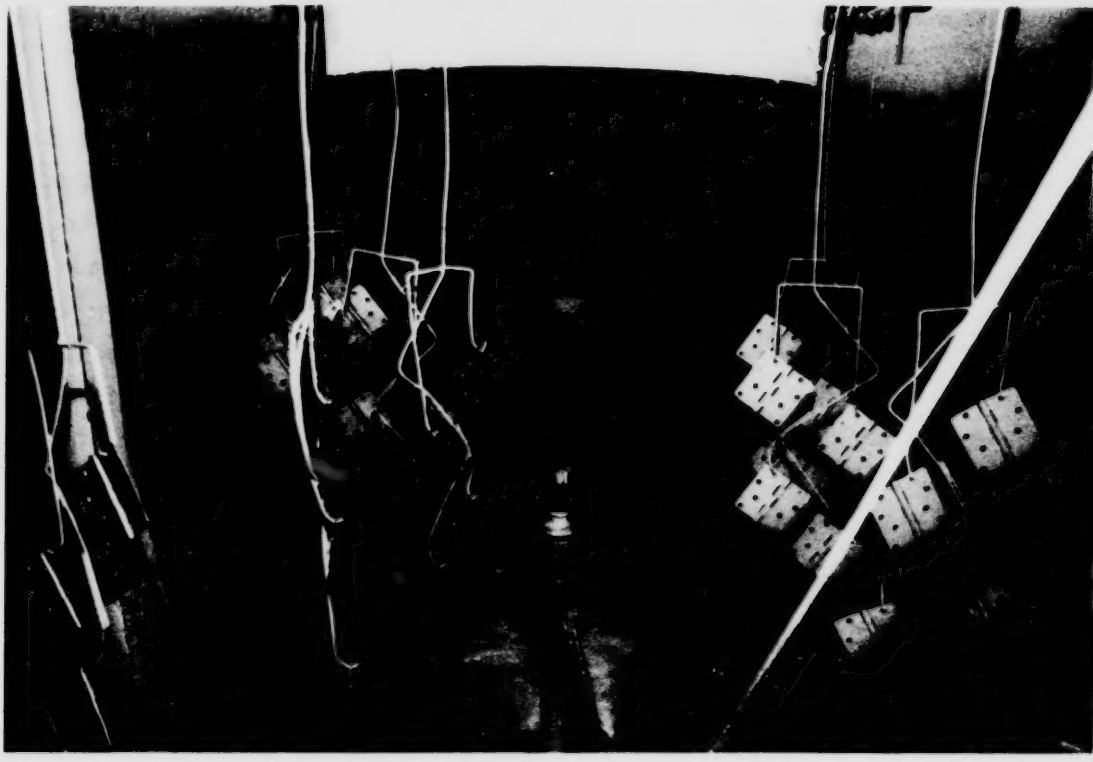
2.4.1 Electrocleaning. Electrocleaning removes the final traces of soil and chemically activates the metal surface for plating. The alkaline bath, similar to that used for soak alkaline cleaning, is composed of caustic, wetting agents, buffering agents, dispersants and other chemicals. As a 3- to 12-volt direct current is applied, the cathodic workpiece repels negatively-charged colloidal soil particles and hydrogen gas is evolved, creating a scouring action. The current may be reversed, causing the workpiece to become anodic and oxygen gas to evolve. The positively-charged workpiece will now repel metal ions and metal smut. Whether a direct, reverse or periodically reversing current is applied depends upon the base metal and the soil to be removed. Nickel and nickel alloys must be cleaned cathodically, for example.

The alkaline bath must be discharged when an excessive soil load has accumulated. A rinse always follows electrocleaning and the effluent contains alkaline cleaners plus soil and metal residues.

2.4.2 Electropolishing. Electropolishing produces an excellent, smooth, pit-free surface, particularly on stainless steels. The workpiece is the anode. Ferrous alloy and copper workpieces use phosphoric and/or sulphuric acid as the electrolyte, the acid



Photograph 6. Manual Spray Painting



Photograph 7. Mechanical Spray Painting

proportions depending on the type of metal. Electropolish processing varies in duration from two to seven minutes.

Rinsing is necessary and adds to the effluent stream acids, bases, metals, soil and oil. Batch discharge of the process acids is required periodically, resulting in a large volume of sludge.

2.4.3 Anodizing. In anodizing, the workpiece acts as the anode and a thin oxide coating is formed on the surface. Most anodizing is performed on aluminium although other metals, such as magnesium, are also treated. Anodic coatings protect against corrosion and abrasion and produce a base for many colouring and decorative effects. Variation in coating thickness and weight is controlled by bath temperature, type, time and voltage.

Sulphuric acid at 12 to 25 percent concentration is an inexpensive and easily controlled 'all purpose' electrolyte for anodizing. Coating thickness may range from 2.5 to 30 μm. Chromic acid anodic coatings are opaque and are often used as a base for paints, particularly in military applications. A bath of 3 to 10% chromic acid applied for about 30 minutes can form an oxide coating of up to 10 μm thickness. Other acids may impart desired porosity, hardness or other surface characteristics. A seal, such as nickel acetate, is required after anodizing.

Wastewater is generated from process and sealing bath discharges, and associated rinse waters containing base metal, chromates, and colouring organics and dyes.

2.4.4 Electroplating. Electroplating is the electro-deposition of a thin metallic coating upon the surface of an object to provide corrosion protection or a decorative finish, or to otherwise affect the appearance and properties of the surface. Metal ions are supplied by the dissolution of metal anodes or the addition of metal salts to the solution. The positive metal ions migrate toward the cathodic workpiece and are reduced upon its surface. The workpieces are usually suspended on a rack or loaded into perforated barrels.

Hundreds of electroplating solutions are used depending on the metals involved, results desired, and costs. Recent environmental concerns have created even more plating bath variations which omit or reduce such constituents as chrome, cyanide and organic additives. As with most surface finishing processes, air emissions may contain hazardous substances that also require collection and/or treatment. The more common electroplated metals and their electrolyte solutions are listed in Table 4.

TABLE 4 ELECTROPLATING BATHS

Nickel			
Bright:	nickel sulphate nickel chloride boric acid sulphonic acids sulphonamides	Acid:	nickel sulphate nickel chloride boric acid
		Black:	nickel chloride ammonium chloride sodium thiocyanate sodium chloride
Semi-bright:	nickel sulphate nickel chloride boric acid coumarin		
Chromium			
Acidic:	trivalent chromium chloride chromic acid sulphuric acid fluosilicic acid		
Copper			
Cyanide:	copper cyanide complex sodium cyanide potassium cyanide sodium hydroxide potassium hydroxide	Pyrophosphate:	copper pyrophosphate potassium hydroxide ammonia
Sulphate:	copper sulphate sulphuric acid		
Zinc			
Cyanide:	zinc cyanide sodium cyanide sodium hydroxide	Sulphate:	zinc sulphate aluminium sulphate sodium acetate glucose or licorice
Chloride:	zinc chloride hydrochloric acid ammonium chloride potassium chloride		
Brass			
	copper cyanide zinc cyanide sodium cyanide		sodium carbonate ammonia

TABLE 4 ELECTROPLATING BATHS (CONT'D)

Tin			
Alkaline:	sodium stannate potassium stannate potassium hydroxide sodium hydroxide	Chloride:	stannous chloride nickel chloride ammonium fluoride ammonium bifluoride sodium fluoride
Acid:	stannous sulphate stannous fluoborate sulphuric acid phenolsulphonic acid fluoboric acid		hydrochloric acid
Cadmium			
Cyanide:	cadmium cyanide cadmium oxide sodium cyanide sodium hydroxide	Acid:	cadmium fluoborate ammonium fluoborate boric acid fluoboric acid
Gold			
	potassium cyanide potassium gold cyanide		
Silver			
	silver cyanide potassium/sodium cyanide potassium/sodium carbonate		potassium hydroxide potassium nitrate carbon disulphide
Lead			
	lead fluoborate fluoboric acid		boric acid hydroquinone
Iron			
	ferrous sulphate ferrous chloride ferrous fluoborate calcium chloride		ammonium chloride sodium chloride boric acid

Nickel plating is an important process in the metal finishing industry because it is so widely used for household articles, appliances, automobiles, furniture, sporting equipment and so on. Nickel adds decorative and protective qualities and is part of the standard combination coating of copper-nickel-chromium on zinc die castings, steel and brass.

Nickel is electroplated from baths containing nickel sulphate, nickel chloride and boric acid. This bath has been the basis of nickel-plating operations since 1916. The emergence of brighteners and semi-brighteners removed the need for buffing decorative finishes and have gained wide use. Cobalt plating, also known as black nickel plating, was developed when nickel anodes were not readily available. It does not offer any advantages over nickel and is more expensive.

Hard chrome plate is an industrial finish applied primarily to resist wear or to restore worn parts. Decorative chrome plate is a thin top-coat, usually over nickel plate. A dissolved chromium salt, hexavalent form, is always the source of chrome in plating baths because soluble chrome anodes are not practical. In the future, hexavalent chrome may be replaced by the less toxic trivalent form. However, this does not produce the same finish and has only recently been introduced in Canada.

The copper cyanide process has the broadest application and is often used in conjunction with nickel and chrome plate. On active metals such as zinc and steel a copper cyanide strike is necessary. Acidic copper baths, such as the copper sulphate bath, have a cost advantage over cyanide baths and are more acceptable environmentally but they cannot replace the cyanide baths for many applications. The copper pyrophosphate bath is important to the electronics industry for plating through-holes in printed circuit boards. This bath is non-toxic although it does contain phosphates.

Cadmium is a moderately expensive metal compared to zinc. Although it offers superior corrosion resistance to alkalis and to marine atmospheres, its toxicity and cost discourage its use. A cyanide bath is commonly used to plate cadmium. Acid baths have been developed to avoid the waste problems involved but the operating conditions required and the deposit quality are not as suitable as with the cyanide bath.

Zinc electroplating is widely used where controlled thicknesses are required for corrosion protection and for decorative appeal. Conventional zinc cyanide baths create environmental problems and, as a result, acidic potassium baths and alkaline zinc baths are being used more widely. The zinc sulphate process is used by steel companies on strip plating lines.

Photograph 8. Bumper Plating Line

Tin plate is used in the food industry for tin foil and tin cans, for food handling equipment, and in the electronics industry. Various plating baths are available, the choice being determined by the end use of the product.

.5 Waste Stream Generation and Characteristics

Surface finishers produce and discharge a variety of waste streams including process wastewaters, spent process solutions, sludges and air emissions. The metal finishing processes that generate these discharges and emissions are shown in Table 5.

.5.1 Wastewaters. For proper plating to occur, the parts must be clean and free of contamination from previous processes. Therefore considerable quantities of raw water (or demineralized) are used to rinse the parts. Depending on the process for which the rinsing takes place, the wastewater produced may be acidic or alkaline and may contain particular metals or combinations, solvents or cleaning solutions, and/or particulates (dirt).

TABLE 5 WASTE STREAM GENERATION AND CHARACTERISTICS

Processes	Wastewaters					Wastes	Air Emissions
	Metal	Chromium	Cyanide	Oils	Solvents		
Deburring	X	X	X	X		X	X
Polishing	X			X		X	X
Solvent Cleaning	X			X	X	X	X
Alkaline Cleaning	X		X	X	X	X	X
Pickling	X	X					X
Etching	X	X					X
Bright dipping	X	X					X
Salt bath descaling	X		X	X		X	
Quenching	X		X	X		X	
Chromating	X	X					
Phosphating	X	X					X
Passivating	X	X					X
Plastic coating					X	X	X
Paint coating	X				X	X	X
Hot dip coating	X						X
Electroless plating	X	X	X				X
Anodizing	X	X					X
Electropolishing	X						X
Electroplating	X	X			X	X	X
Electrocleaning	X		X	X	X	X	X

Another source of wastewater contamination comes from floor drains. Often, through poor housekeeping, plating solution is allowed to drip as the rack or barrel is passed from tank-to-tank, and this solution subsequently finds its way into the plant's sewer system.

2.5.2 Hazardous Wastes and Sludges. Several waste streams, including spent process solutions and sludges, are considered 'hazardous'. Hazardous wastes are those wastes which, due to their nature and quantity, are potentially hazardous to human health and/or the environment and which require special disposal techniques to eliminate or reduce the hazard. Any substance or mixture being discarded is considered hazardous if it is flammable, carcinogenic, toxic, corrosive, explosive or meets other criteria developed by a federal-provincial working group. Table 5 summarizes the types of wastes generated by surface finishers while Table 6 lists the hazardous wastes recognized in the Transportation of Dangerous Goods Act (TDGA) (6).

TABLE 6 HAZARDOUS WASTES GENERATED BY SURFACE FINISHING

TDGA Code No.	Waste Type No.	Source	Waste Component(s)
NA 9301	1	solvent degreasing	The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.
NA 9302	2	solvent degreasing drying painting coating machining miscellaneous	The following spent halogenated solvents: tetrachloroethylene, methylene chloride, trichloroethylene, 1,1,1-trichloroethane, chlorobenzene, 1,1,2-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, and trichlorofluoromethane; and the still bottoms from the recovery of these solvents.
NA 9303	3	solvent degreasing drying painting coating machining miscellaneous	The following spent halogenated solvents: xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclohexanone; and methanol; and the still bottoms from the recovery of these solvents.
NA 9304	4	solvent degreasing	The following spent non-halogenated solvents: cresols and cresylic acid, nitrobenzene; still bottoms from the recovery of these solvents.
NA 9305	5	solvent degreasing	The following spent non-halogenated solvents: toluene, methyl ethyl ketone, carbon disulphide, isobutanol, and pyridine; and the still bottoms from the recovery of these solvents.
NA 9306	6	effluent treatment	Wastewater treatment sludges from electroplating operations except for the following: (1) sulphuric acid anodizing of aluminium; (2) tin plating on carbon steel; (3) zinc plating (segregated basis) on carbon steel; (4) aluminium or aluminium-zinc plating on carbon steel; (5) cleaning/stripping associated with tin, zinc, and aluminium plating on carbon steel; (6) chemical etching and milling of aluminium.
NA 9307	7	effluent treatment	Wastewater treatment sludges from the chemical conversion coating of aluminium.
NA 9308	8	electroplating	Spent cyanide plating bath solutions electroplating operations except for precious metals electroplating spent cyanide plating bath solutions.
NA 9309	9	electroplating	Plating bath sludges from the bottom of plating baths from electroplating operations where cyanides are used in the process (except for precious metals electroplating plating bath sludges).
NA 9310	10	cleaning	Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions).
NA 9311	11	quenching	Quenching bath sludge from oil baths from metal heat treating operations where cyanides are used in the process (except for precious metals heat treating quenching bath sludges).
NA 9312	12	salt bath pot cleaning	Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations (except for precious metals heat treating spent cyanide solutions).
NA 9313	13	effluent treatment	Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process (except for precious metals heat and treating quenching wastewater treatment sludges).
NA 9381	81	pickling	Spent pickle liquor from steel finishing operations.
NA 9382	82	effluent treatment	Sludge from lime treatment of spent pickle liquor from steel finishing operations.

Spent process solutions include:

a) acidic waste from pickling, etching, bright dipping and electropolishing,
b) alkaline cleaning baths and electrocleaning baths,
c) solvent degreasing waste,
d) salt bath descaling solution, and
e) spent baths themselves when they can no longer be rehabilitated.

The acidic waste contains a high level of dissolved metals, oils and suspended particles. Acids contained in the spent liquors or wastewaters, if discharged to sewer, can corrode the sewer line and damage municipal treatment facilities. Alkaline discharges have similar undesirable characteristics and effects. The large number of different compounds and additives in cleaning solutions often make recovery of metals or chemicals from the spent solutions impractical.

Solvent waste contains soil and oily buildup. This waste can interfere with sewage pumps, pH sensors and other effluent treatment equipment. Solvents themselves are toxic and classified as hazardous (Table 6). Oily waste is composed of free oil, emulsified oil, and grease. Many additives and organic priority pollutants are soluble in hydrocarbons and are found in the oily layer of cleaning waste. Oils affect the odour and taste of water and are harmful to aquatic life. A moderately sized surface finishing operation will generate about 5 m^3 of solvent and oily waste annually. Solvents and oils should be separated from aqueous waste and recovered by distillation (if feasible) or suitably disposed.

Spent plating and coating solutions are generated during electroplating, electroless plating, hot dip coating, anodizing and chemical conversion coating operations. These wastes, and the relating rinsewaters, may be acidic or alkaline and may contain hexavalent and trivalent chrome, cyanide and other toxic compounds.

A number of metal finishing operations leave sludges on the bottoms of plating bath tanks. Large amounts of sludge are also formed during cleaning, painting and effluent treatment. Sludge from effluent treatment is only one to five percent solids and can be dewatered to reduce its volume. Sludges usually contain hazardous materials which could upset the municipal treatment plant if discharged to sewer.

2.5.3 Air Emissions. Air emissions from surface finishing operations include volatile organic compounds (VOC), acid mists, metal and abrasive dust, and grit generated during polishing and buffing. VOC, from all solvent related operations, particularly degreasing

and printing, may be nasal and lung irritants; they may aiso contribute to photochemical oxidant problems. Acid mists, from open acid baths and particularly heated baths, as well as metal and abrasive dust and grit generated during polishing and buffing, may be health hazards in the work area. Chromium solutions are an example of an acidic mist which must be properly handled.

2.6 Wastewater Treatment Technologies

Wastewater treatment technologies employed by surface finishers include in-plant water conservation measures to minimize effluent discharges, as well as end-of-pipe treatment.

2.6.1 Water Conservation. Water conservation results in lower water use and less effluent to treat. Savings can be realized in the capital cost of lower capacity treatment equipment, chemical costs, and conserved floor space.

Rinse tanks follow almost all surface finishing operations and are the largest source of wastewater. The amount of rinse water used can be reduced by at least one-half by:

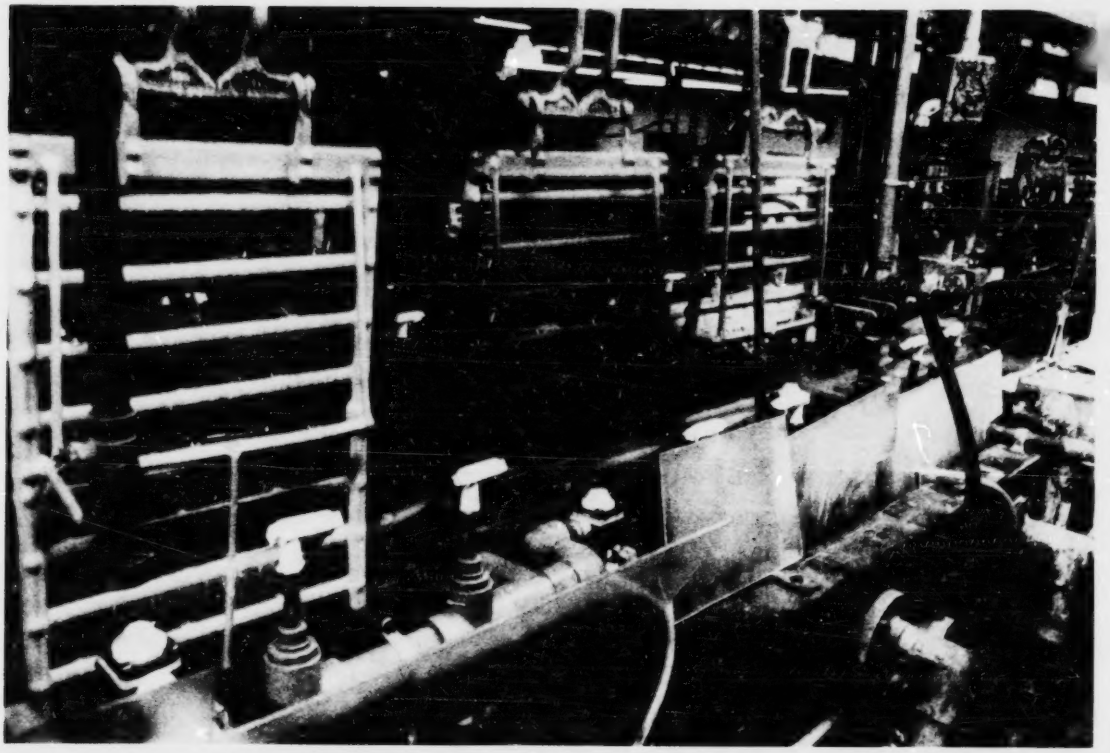
a) counterflow rinsing (at least two stages are required but usually no more than four);
b) spray rinsing, which consumes less water than the conventional bath;
c) conductivity meters in rinse tanks so that slightly contaminated water can be re-used to its full extent;
d) flow control valves set at minimum fresh water flow requirement;
e) delay over plating baths and rinse tanks to reduce dragout to the following tank; and
f) drag-in/drag-out tanks before and after plating tanks.

Unnecessary wastage of process solutions can be prevented by:

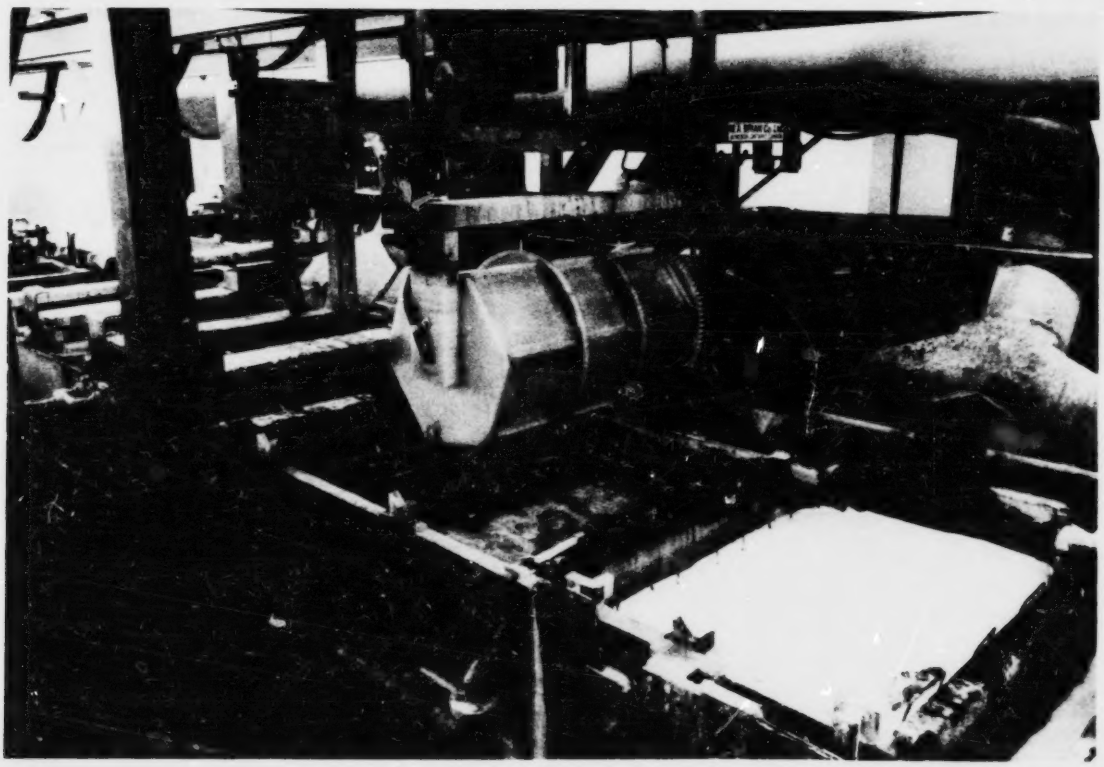
a) the use of holding tanks or dams to retain splashes, spills and leaks; and
b) segregation of acids, alkalis, cyanide and chrome wastes by trenching and piping.

2.6.2 Effluent Treatment. Effluent treatment options used by surface finishers are summarized in Table 7.

1) Cyanide Chlorination. Cyanide-containing effluents from plating, conversion coating and cleaning are oxidized to break down the cyanide to carbon dioxide and nitrogen. The most common treatment method is alkaline chlorination because the operating costs are low, the process can be automated and efficiencies of 99 percent reduce the cyanide to very low or undetectable concentrations.



Photograph 9. Spray Rinsing Conserves Water



Photograph 10. Delay over Rinse Tank Reduces Dragout

TABLE 7 SUMMARY OF EFFLUENT TREATMENT OPTIONS

Process	Purpose
Alkaline Chlorination	Cyanide oxidation to carbon dioxide and nitrogen
Electrolytic destruction	Cyanide destruction to nitrogen, carbon dioxide and ammonia
High-pressure and high-temperature hydrolysis	Cyanide destruction to ammonia and formate
Chromium reduction	Hexavalent chrome reduced to trivalent chrome
Hydroxide precipitation	Precipitation of metals, trivalent chrome, phosphates
Sedimentation	Removal of suspended solids (generated from hydroxide precipitation)
Reverse osmosis	Recovery of metal salts and organic solutes
Electrodialysis	Recovery of metal ions from rinsewater
Ion exchange	Recovery of metal ions from rinsewater
Evaporation	Recovery of plating chemicals from rinsewater

The reaction takes place in two steps. The first occurs at a pH of 11 and lasts about 10 minutes. The second reaction takes place in a separate tank with a solution pH of 8 and a residence time of about 30 minutes. Caustic or lime, and elemental or hypochlorite chlorine, are used to control the pH as well as the oxidation reduction potential (ORP). Metals in the cyanide stream, such as nickel, iron and copper may inhibit the cyanide destruction. Unless operating conditions are correct, undesirable toxic reaction by-products can form.

Alternatives to alkaline chlorination have been recently developed and are commercially available. These include ozonation, ultraviolet radiation, hydrogen peroxide and electrolytic oxidation. However, these methods may be more expensive and require specially trained operators.

2) Electrolytic Destruction of Cyanide. The electrolytic destruction of cyanide is applied to heat treatment waste and concentrated cyanide dumps, although it may also be used to treat high-concentration cyanide plating baths.

A direct current is applied to the cyanide waste and nitrogen, carbon dioxide and trace amounts of ammonia are produced and vented off as gas. The process lasts a few hours and has the advantages of low operating costs and no chemical requirements.

The use of electrolytic destruction is limited to wastewaters with cyanide concentrations of over 100 mg/L. Below this level, conductivity is reduced and the reaction normally cannot proceed. Sulphates in the waste inhibit process performance.

3) High-Pressure and High-Temperature Hydrolysis. A hydrolysis process to destroy cyanide in dilute rinse waters and spent plating solutions has been developed recently and may provide surface finishers with an economical alternative to chlorination (7).

In this process, cyanide is hydrolyzed to ammonia and formate at operating conditions of 6200 kPa (900 psi) and at least 200°C. The conversion efficiency is high, but some plating effluents may hydrolyze at slower rates than others. High-pressure, high-temperature hydrolysis is estimated to offer a 15 to 35 percent cost savings compared to standard chlorination and has the advantage of using no chemicals.

4) Chromium Reduction. Chromium effluents are generated during electroplating, chromate conversion coatings, etching, and any cleaning operation on chrome metal. Chromium can be precipitated and removed as a hydroxide after being reduced to its less toxic trivalent form. The reduction is commonly carried out with either sulphur dioxide or metabisulphite as the reducing agent. Sulphuric acid is added to lower the pH to 2 or 3. The reducing agent is metered in to reach an oxidation-reduction potential of 250 to 300 millivolts and complete reduction occurs in a couple of hours.

This process is effective, can be automated and has a low energy consumption. However, chemical costs are high and sulphur dioxide, the standard reducing agent, can be hazardous to store and handle. Oxidizing agents in the waste, such as dissolved oxygen or ferric ions, can interfere with chromium reduction.

Alternatives to chemical reduction are electrochemical chromium reduction, electrochemical chromium regeneration, evaporation and ion exchange.

5) Neutralization and Hydroxide Precipitation. Neutralization is required for the large volume of acidic effluents generated during acid cleaning, acid cleaning rinses and plating rinses. A smaller amount of alkaline effluents results from detergent and alkaline cleaning and is usually combined with the acid stream.

A slurry of lime or sodium hydroxide, whichever is available, is added to the acid effluents. If metals are present in the waste stream, which is invariably the case for

surface finishers, an alkaline pH level will cause metal hydroxides to form within minutes. Coagulating agents may be added to enhance coagulation and precipitation. Different metals will precipitate at different pH levels, ranging from 8 to 11. Phosphates will also precipitate out of solution as calcium phosphate. Cyanides, complexed metals and hexavalent chrome will not precipitate.

Hydroxide precipitation of metals is the most common treatment process. It has a long history of use, is usually very effective and can be automated. The use of expensive chemicals and electrical power is avoided. Cyanides and complexed metals must be broken down prior to hydroxide precipitation because they inhibit this process.

6) Sedimentation. After neutralization and hydroxide precipitation, the suspended solid particles formed can be removed by gravity settling in a sedimentation basin or clarifier. Coagulants or flocculents may be added to shorten the retention time of several hours and increase removal efficiency. Clarifiers are the preferred equipment because they offer a shorter retention time, higher efficiency, and are more compact than sedimentation basins.

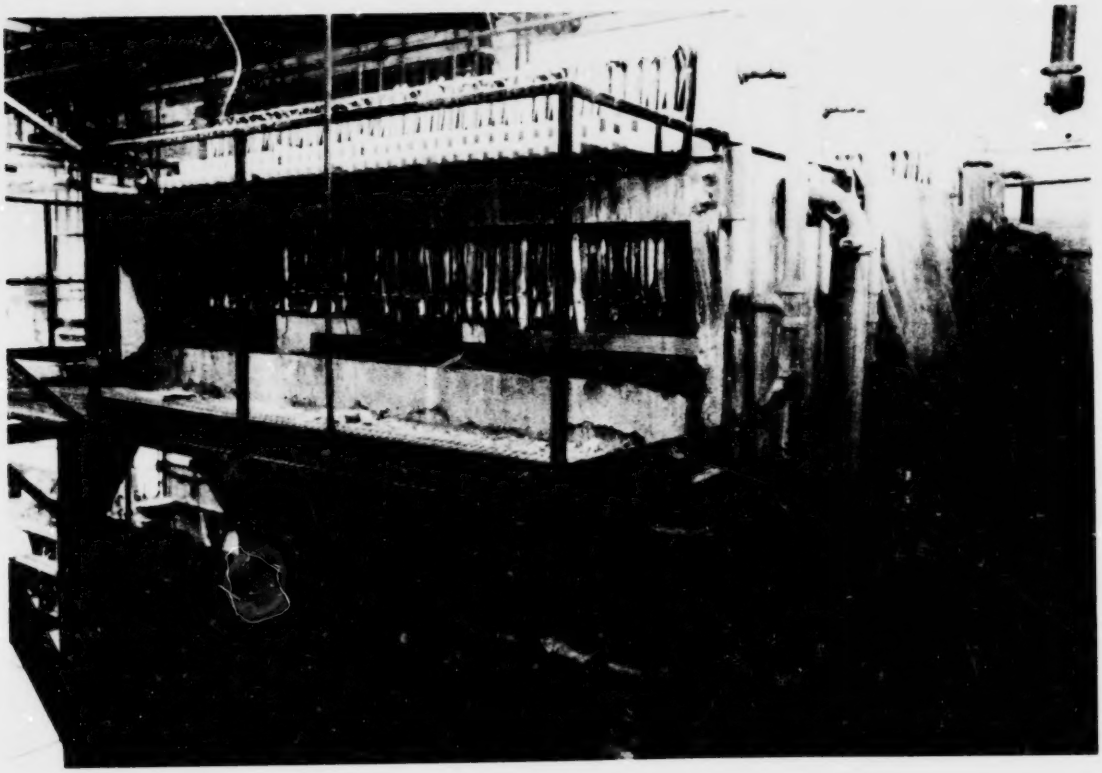
Large volumes of metal hydroxide sludge are removed from the effluent but this sludge has no commercially viable recovery potential at present. It may, however, be hazardous and must be disposed of at an accepted landfill site. To reduce transportation and disposal costs the sludge should be dewatered to increase the solids content from about 2 percent to 40 or 50 percent. Plate and frame filters offer the lowest operating cost but large plants often use vacuum filters for dewatering.

If the system is well operated, effluent from sedimentation should meet municipal by-law requirements for suspended solids and metals. The use of sand filters to polish the effluent following clarification is generally recommended to ensure that small amounts of floc and the solids from temporary clarifier upsets do not reach the plant outflow.

7) Electrodialysis. Electrodialysis is a method of recovering and concentrating the metal ions in plating rinse waters for recycle to the plating bath. It has been used commercially to recover chromic acid etch solution and copper cyanide plating chemicals. Other plating rinses can also be treated by electrodialysis.

The electrodialysis unit is a parallel group of membrane pairs. The rinse stream to be treated is filtered and pumped to the membrane stack. Each pair of membranes in the stack is called a cell; one membrane is anion selective, the other is cation selective. Negative and positive ions are drawn through the respective membranes

Photograph 11. Wastewater Clarifier



Photograph 12. Pressure Filters

leaving non-ionic constituents in the diluted stream. The concentrated stream is returned to the plating bath. The diluted stream can be used as the initial rinse or, because it still has a mineral content of 1000 mg/L, it must be further treated prior to discharge.

Electrodialysis is relatively new and, although there are a wide number of uses for this recovery process, it has not yet gained popularity, perhaps because of its high capital cost.

8) Reverse Osmosis. Reverse osmosis (RO) is the process of applying a gauge pressure of 2750 to 5500 kPa (400 to 800 psig) to force permeate through a semipermeable membrane into a dilute solution. It has found many applications including reclaiming of plating salts, and recovering specific solutes, such as latex resin from paints. In Canada, however, very few RO systems are in use.

Reverse osmosis has been particularly successful at recovering nickel salts from spent nickel plating and rinse baths. Payback periods of about three years have been realized. Other applications are the recovery of zinc chloride, copper cyanide, zinc cyanide and cadmium cyanide. An important and valuable by-product of reverse osmosis is pure water which can be recycled back to the rinse tanks (8).

Advantages of RO are the comparatively low power requirements, high capacity and possible good recovery. However, it is limited by the narrow temperature, pH and concentration ranges the membrane will tolerate. RO has not been successful on chromic acid, strongly acidic or basic solutions, or solutions containing oxidizing agents or solvents. A fouled membrane can be replaced at a cost of about $5000 and this replacement may last one to four years. Future research may develop more acceptable membranes; cellulose acetate is a promising material.

9) Ion Exchange. Ion exchange is another metal recovery process which removes and concentrates metals in plating rinsewater (9). In some cases the metals recovered by the ion exchange unit can be returned to the plating bath. Nickel, for example, can be recovered as nickel chloride or as nickel sulphate. The rinse water is usually recirculated after this treatment. Another important use of ion exchange is the purification of hexavalent chromium baths. Rather than discard the bath when contaminants have built-up, unwanted metals, calcium, trivalent chrome and sodium impurities can be removed in the cation exchanger. Ion exchange units are used in many Canadian surface finishing plants.

During ion exchange, metal ions in solution are exchanged for harmless ions of a similar charge on the resin surface. The waste stream is filtered and fed to the cation

exchanger, where copper, ion, nickel, sodium, calcium and trivalent chromium are retained on the resin in exchange for hydrogen ions. The stream then flows through the anion exchanger where chlorides, carbonates and nitrates are retained in exchange for hydroxyl ions. This circuit may be repeated as necessary in order to remove contaminants to the desired level.

When the resin surface is spent, it can be regenerated. The cation resin is regenerated by hydrochloric or sulphuric acid to remove the metal deposits and leave hydrogen ions in their place on the resin surface. The anion resin is regenerated with sodium hydroxide, leaving hydroxyl ions on the resin surface. The concentrated metal solution produced by resin regeneration may be used in the plating bath, as in the case of nickel or chrome plating but, in many cases, it is a waste stream.

10) Evaporation. Evaporating water from rinses yields a concentrated solution of process chemicals and a purified condensate. The condensate does contain some metal carry over but still can be reused as a final rinse. The concentrate recovered can be returned to the plating bath.

An evaporator and ion exchange unit together may continuously recover and purify plating solution and rinse water in a closed-loop system. Open-loop systems allow the use of additional rinse water in excess of the evaporator capacity.

Many types of evaporators are commercially available. Submerged tube evaporators are commonly used because of their lower capital cost. Vacuum evaporators must be used to recover cyanide baths because they operate at a lower temperature and therefore do not destroy the cyanide. Atmospheric evaporators are often used to recover chromic acid from scrubber units.

Evaporators have a higher capital cost than other recovery systems, and high power costs are associated with steam generation. At a large plant, chromium, nickel or cyanide recovery from rinse waters may contribute to a favorable payback period and savings will also be realized if conventional treatment of rinse waters can be avoided (9).

2.7 Control of Air Emissions

The pollutants present in air emissions from surface finishing operations include particulates, volatile organic compounds (VOC) and acid mists. These pollutants may be toxic and harmful to plant workers as well as to the surrounding environment. Some are transported long distances and may contribute to ozone formation and acid precipitation. The control of air contaminants may be approached in three ways:

a) substitution of less hazardous materials or processes,
b) dispersion of the pollutant to acceptable concentrations, or
c) treatment or removal of the pollutant from the emissions.

The substitution of less toxic solvents for hazardous solvents is the most desirable practice. Solvent-based conventional paints often may be replaced with water-based or high-solids paints, which have a low solvent content.

Concentrations of air pollutants in the work place can be minimized by ventilation. Exhaust hoods partially enclosing open tanks can remove contaminated air from the plating area to outside as long as municipal and provincial air quality emission regulations are met.

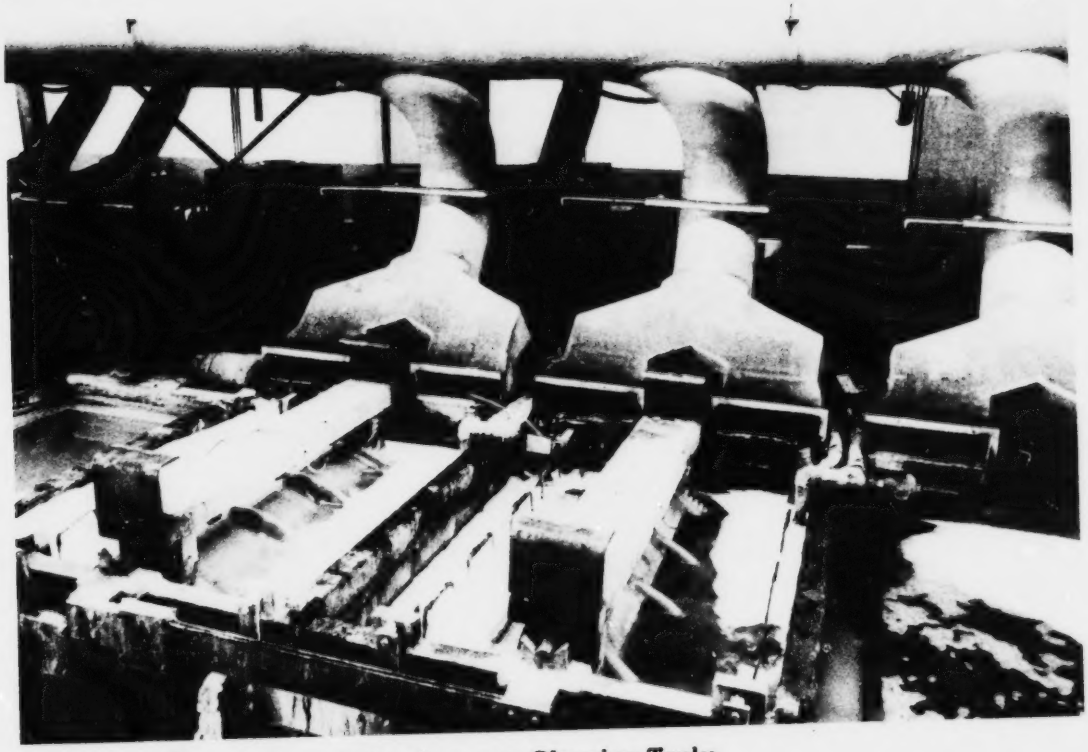
Open-tank operations from which mist, spray and volatile components may escape are pickling, cleaning, plating, degreasing, coating and some rinses. In addition to local ventilation, air emissions may be reduced by surface foam inhibitors or plastic chips or balls. Condensation coils above tanks containing volatile solvents and heated baths can prevent the escape of vapour.

Particulates are produced during mechanical surface preparation and consist of abrasives, dirt and metal dust. Cyclones and dust collectors can remove these coarse particles from wet or dry air flows. The entrained particles lose their velocity when they impact the sides and the force of gravity causes them to fall out of the air stream. Cyclones have low capital and operating costs.

Fabric filters, or bag filters, allow the air to pass through while particles collect on the filter medium. Periodically the filter is cleaned by reverse flow, shaking or other methods. Fabric filters are applied when a low volume, low humidity stream must be cleared of particulates with high efficiency. Due to the cost of the filter medium, capital cost is high for this treatment operation.

Mist eliminators capture liquid particles formed by spraying and should be used over acid cleaning baths and electroplating baths with an integrated ventilation system (if a fume scrubber is not being used). Most operate by slowing down the air flow with directional changes. Liquid particles hit the sides and drop out of the air stream and are drained out.

Fume scrubbers remove liquid, solid and gaseous pollutants from air emissions by the action of a fluid, usually water. Pollutants are dissolved in the fluid which is sprayed over a packed bed. This fluid can be recirculated with a make-up stream to economize its use. The spent fluid waste should be treated. In some cases, such as for



Photograph 13. Vapour Collection over Cleaning Tanks

Photograph 14. Ventilation for Particulate Control

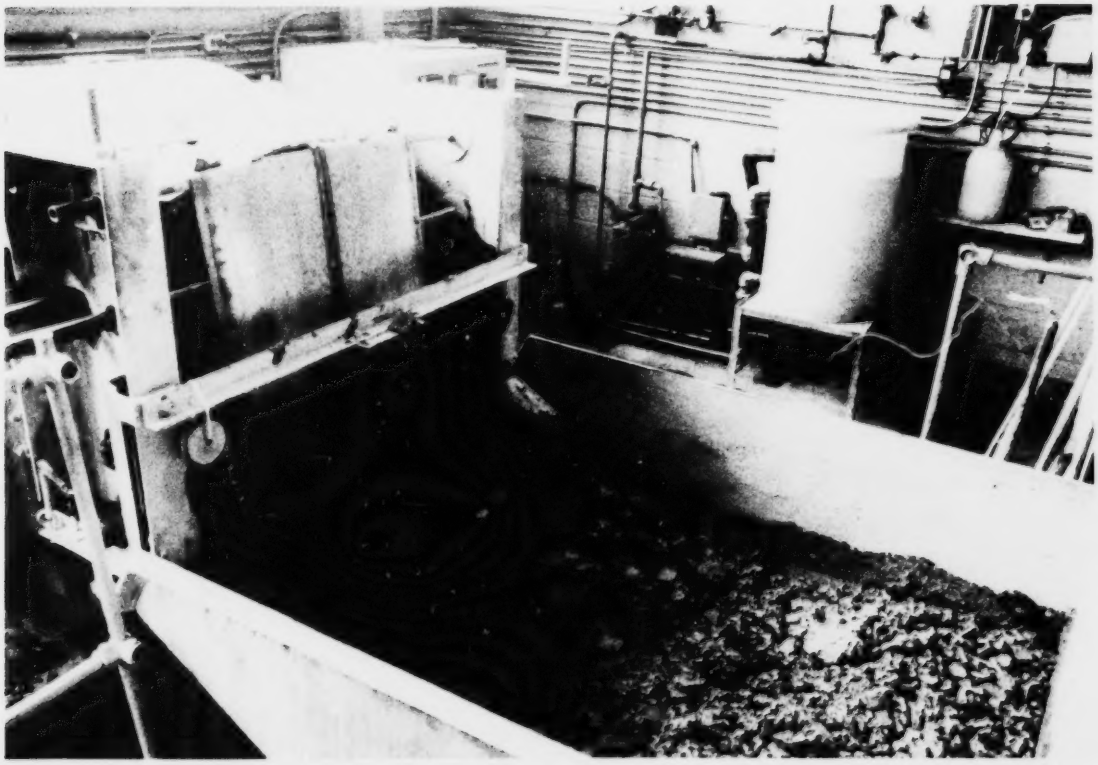
chrome-plating emissions, the scrubber fluid can be returned to the plating tank when spent to make up for evaporative losses and dragout.

Fume scrubbers are used on pickling, etching, bright dipping, plating, electroless plating, anodizing and phosphating lines. Units can be designed to handle high temperature and corrosive streams. Efficiency of removal of water soluble pollutants is high at 99 percent. Capital costs range from moderate to high and operating costs, because of the large volume of water and power required, are also high.

2.8 Hazardous Waste Disposal

As mentioned in Section 2.6, hydroxide sludges from the wastewater treatment plant can be dewatered using filter presses or other techniques. In some cases, these sludges have been co-disposed with municipal refuse at landfill sites. This is not recommended because the acidic decomposition of refuse will result in metals being leached from the hydroxide sludge.

Hazardous waste disposal sites are scarce in Canada and this has resulted in some of the spent process bath solutions being stored on-site or disposed of to a sewer.



Photograph 15. Dewatered Sludge

Neither of these strategies can be condoned. There are some reputable transporters and hazardous waste disposal facilities across the country. The Stablex Canada Ltd. operation in Quebec is designed to handle inorganic wastes, while Tricil (Sarnia) Ltd. in Ontario operates a facility that handles both inorganic and organic wastes. The Alberta Special Waste Treatment Centre located in Swan Hills is scheduled to open in September, 1987.

Some of the solidification techniques appear promising but are not yet being used by any plants in Canada.

3 REGULATORY CONTROL

This section presents the regulations and guidelines that apply to air emissions, liquid effluents and solid wastes generated in surface finishing operations. Enforcement of these controls is also discussed.

3.1 Federal

The federal government is empowered by the Fisheries Act to promulgate regulations to limit the discharge of substances deleterious to fish. In 1977, Fisheries and Environment Canada issued the "Metal Finishing Liquid Effluent Guidelines" to limit pollutant discharges from surface finishers. Guidelines are not actual laws, but provide a baseline standard for discharges. The limits set for direct discharges to water courses in the guidelines are shown in Table 8. The guidelines also recommend good "housekeeping" practices as well as sampling and record keeping procedures.

TABLE 8 FEDERAL METAL FINISHING LIQUID EFFLUENT GUIDELINES FOR DIRECT DISCHARGES (2)

Substance	Maximum Total Concentration (mg/L)
Total suspended matter	30
Cadmium	1.5
Chromium (total)	1.0
Cyanide (oxidizable)	0.1
Cyanide (total)	3.0
Copper	1.0
Lead	1.5
Nickel	2.0
Zinc	2.0

The Transportation of Dangerous Goods Regulations, promulgated by Transport Canada in February, 1985, under the Transportation of Dangerous Goods Act (TDGA) regulate the handling, offering for transport and transporting of goods considered to be "dangerous". Many of the wastes generated by surface finishers are listed as "dangerous goods" under the TDGA (Table 6). The regulations specify information that must be stated in manifests, and outline requirements for labels, placards, signs and precautions relating to temperature control, limitations on quantities, emergency response planning and other safety standards.

No federal regulations or guidelines have been issued to control air emissions from surface finishing operations.

3.2 Provincial

Each provincial ministry of environment is responsible for establishing regulatory requirements to protect the province's soil, water and air quality. In some provinces this responsibility is shared with other agencies such as the provincial ministry of agriculture or the ministry of health. Regulatory controls are developed only where a need exists and may include provisions governing any or all of the following:

a) discharges to sanitary sewers,
b) discharges to storm sewers or water sources,
c) municipal landfill operations,
d) industrial private landfill operations,
e) industrial effluents,
f) municipal sludge application on land,
g) municipal treatment plant effluent quality,
h) air quality, ambient and point source, and
i) water quality objectives.

Provincial governments may also own and operate wastewater treatment plants.

3.2.1 Atlantic Provinces. The provincial governments in the Atlantic region have no specific air emission or liquid effluent standards for surface finishers. Industries must obtain a permit to discharge and the federal guidelines are usually applied. Case-by-case review is also used for sludge disposal.

3.2.2 Quebec. In Quebec, regulations for discharges to sanitary sewers and storm sewers (water courses) have been drafted under the provincial Environmental Quality Act; the pollutant limits set by the proposed regulations are shown in Tables 9 and 10. Air emission standards have also been established for the metal finishing industry as follows (11):

particulates	25 mg/m^3
chromium acid mist	2 mg/m^3
other acid mist	10 mg/m^3

TABLE 9 QUEBEC DRAFT REGULATIONS FOR DISCHARGES TO SANITARY SEWER (10)

Substance	Concentration Range* (mg/L)
Phenols	0.1 - 1
Cadmium	3 - 8
Chromium	3 - 10
Cyanide (total)	2 - 5
Copper	3 - 8
Lead	3 - 10
Nickel	3 - 10
Mercury	0 - 0.01
Zinc	3 - 10

* Lowest value corresponds to population of 5000 or less. Highest value corresponds to population of 20 000 or more served by sewer system.

TABLE 10 QUEBEC DRAFT REGULATIONS FOR STORM SEWER OR DIRECT DISCHARGES (10)

Substance	Maximum Total Concentration (mg/L)
Phenols	0.020
Cadmium	1.
Chromium	1.
Cyanide (total)	0.1
Copper	1.
Nickel	1.0
Mercury	0
Zinc	1.

3.2.3 Ontario. The Ontario Ministry of the Environment has published model municipal by-laws for discharges to sanitary sewers (Table 11) and for discharges to storm sewers and water courses (Table 12). These limits are based on the Ontario Water Resources Act. There are no regulations that specifically address surface finishing.

The province enforces municipal landfill operation regulations which limit the type of sludges accepted at these sites. Sludges with high metal concentrations must be disposed at approved industrial landfills. The province is also active in leachate sampling programs. Landfills must have proper drainage, leachate sampling holes and, if the quantity is sufficient, leachate recovery and transport to a municipal sewage treatment plant.

TABLE 11 ONTARIO MODEL MUNICIPAL SANITARY SEWER-USE BY-LAW LIMITS (12)

Substance	Maximum Total Concentration (mg/L)
Phenols	1.0
Cadmium	2.0
Chromium	5.0
Copper	5.0
Cyanide	2.0
Lead	5.0
Mercury	0.1
Nickel	5.0
Zinc	5.0

TABLE 12 ONTARIO MODEL MUNICIPAL STORM SEWER-USE BY-LAW LIMITS (12)

Substance	Maximum Total Concentration (mg/L)
Phenols	0.02
Suspended solids	15
Cadmium	0.1
Chromium	1.0
Copper	1.0
Cyanide	0.1
Lead	1.0
Mercury	0.001*
Nickel	1.0
Zinc	1.0

* Federal Government Regulation

Digested sludges produced by Ontario municipal sewage treatment plants are often applied as soil conditioners to farmlands. Strict limits for metals addition to soil are provided in the province's "Guidelines for Sewage Sludge Utilization on Agricultural Lands" (13). These are rigidly enforced, "to protect foodlands from industrial contamination while safeguarding the quality of food, the health of food consumers and the quality of the natural environment generally". If municipal sludge does not meet these guidelines, it may be disposed at the municipal landfill. There have been cases where municipal sludge has not been accepted at the municipal landfill because of high metals content (14).

Such incidents illustrate the problems created by excessive discharges of metals to municipal sewers.

Incineration is one alternative to be considered in these situations. A secure landfill operation is another option that a municipality might consider. However, each of these alternatives is costly and wastes a potential resource.

The Ontario Ambient Air Quality Criteria restrict certain air contaminants at point source (15). Contaminants of interest to metal finishers are listed in Table 13.

TABLE 13 ONTARIO AMBIENT AIR QUALITY CRITERIA REGULATIONS (15)

Contaminant	Unit	Average Concentration	Period of time
Cadmium	mg Cd/m^3 air	2.0	24 h
Nickel	mg Ni/m^3 air	2.0	24 h
Suspended particulate matter	mg SPM/m^3 air	120 60 (geometric mean)	24 h 1 year

3.2.4 Manitoba and Saskatchewan. Manitoba and Saskatchewan do not have provincial effluent or air emission standards that address surface finishing operations. A permit system for liquid effluent discharges to surface waters is practiced. Manitoba Order in Council No. 152 gives the City of Winnipeg control over effluent discharges within the city.

3.2.5 Alberta. In Alberta, metal finishing effluents discharged to municipal sewage systems are subject to compliance with "Guidelines for the Control of Industrial Wastes Discharged to Municipal Sewage Systems" (16). Industries that do not discharge to a municipal sanitary sewer must obtain a permit under the provincial Clean Water Act to discharge to a water course.

Municipal sludge utilization on land is practiced in Alberta and strict guidelines for its application have been established (17). Municipalities require provincial permits for sludge utilization on land and for effluent discharge.

3.2.6 British Columbia. There are no provincial regulations specifically for metal finishing wastes or emissions in British Columbia. Effluent quality criteria for miscellaneous chemical industries discharging to marine or fresh water are listed in Table 14.

TABLE 14 BRITISH COLUMBIA EFFLUENT QUALITY OBJECTIVES FOR CHEMICAL INDUSTRIES - DISCHARGE TO MARINE OR FRESH WATERS (18)

Substance	Maximum Total Concentration (mg/L)
Suspended solids	20.0
Chromium	0.2
Copper	0.1
Cyanide	0.1
Nickel	0.2
Zinc	0.2

3.3 Municipal

Legislation in most provinces assigns to municipalities the authority to set and enforce sanitary sewer-use by-laws to protect their sewage collection and treatment facilities. In addition, municipalities must meet provincial requirements for discharges to storm sewers and for municipal sewage treatment plant effluents. Many municipalities own and operate landfill sites or regulate privately-owned landfills. Municipal and private landfills can only be operated with provincial permits.

Most municipalities have a permit system for industries connecting to the sanitary sewer line. In Ontario, many municipalities have adopted the model by-law limits shown in Tables 11 and 12 (13). In Montreal, plating industries are required to install pretreatment systems by Montreal Urban Community authorities. In Winnipeg, the municipal sewer by-law is being expanded to include limits for metals.

Surface finishers, particularly small to medium sized job shops, have been repeatedly identified as the source of sewer line damage, municipal treatment plant upset and municipal effluent and sludge metal levels that exceed provincial requirements (14). Acidic and plating waste batch discharges to sanitary sewers are often the causes of these problems. Surface finishing wastewaters discharged to storm sewers or combined sewers are also a major source of concern.

3.4 Monitoring and Enforcement

The federal government does not monitor compliance with the Metal Finishing Liquid Effluent Guidelines unless a provincial government requests it. Each provincial government carries out some degree of sampling and inspection through its Ministry of Environment. These programs may be assisted by the Environment Canada's regional

offices; this is the case in New Brunswick, Quebec and Manitoba. Provincial enforcement programs include:

a) municipal landfill inspection,
b) industrial landfill inspection,
c) leachate sampling,
d) municipal effluent sampling,
e) municipal sludge sampling for landfill disposal and application on land,
f) industrial effluent and sludge sampling for industries outside any municipal jurisdiction,
g) freshwater and marine water sampling, and
h) ambient air quality monitoring.

Municipalities are responsible for their own collection and treatment facilities and the enforcement of their own by-laws. Enforcement activities vary from none whatsoever to routine sampling. The costs of sampling equipment, staff and laboratory facilities are deterrents to monitoring in small municipalities. By-law enforcement programs are funded by municipal taxes, surcharges and water-use charges.

4 RESULTS OF THE 1983-84 SURVEY

Results of the 1983 survey of surface finishing operations are given in Appendix D. Results of the 1973 survey are summarized in Appendix E for comparison.

There are an estimated 644 surface finishing operations in Canada; 539 completed and returned the questionnaire. The survey omits 105 known surface finishing operations which either were not contacted or did not respond. In some regions a modified version of the questionnaire was used or information was provided from other sources. The variance in data is evident in the tables in Appendix D. Although cooperation from the surface finishers who did participate was good, some companies did not report waste quantities, descriptions or disposal methods accurately. A small number of companies were telephoned to verify questionnaire responses.

4.1 General Data

Table D-1 is a breakdown of the industry by standard industrial classification (SIC). Companies practicing surface finishing operations are divided according to their SIC and the number in each province as well as the total number in Canada are given. Table D-1 shows that fabricated metal, electrical and transportation equipment are the major industries using surface finishing processes. About 55 percent of the 539 companies are located in Ontario while 24 percent are in Quebec.

Table D-2 provides data related to size of operations. Results from all provinces indicate that the number of surface finishers may have increased but the size of operations has not. Two-thirds of surface finishers responding to this question had less than 10 employees. The largest captive and job shops are located in Ontario. Captive operations account for 60 percent of the responses and 40 percent of employment related to surface finishing. The product value of captive and job operations is comparable. Forty-eight percent of those responding reported sales over $1 000 000 per year. Only 88 responses to this question were received and these were mainly from Ontario and British Columbia.

Tables D-3 to D-6 list the number of companies according to their processes. Table D-3 describes those companies using chemical treatment processes which include vapour and liquid degreasing, alkaline cleaning, pickling, bright dipping, immersion stripping, alkaline and acid etching, chromating/passivating and phosphating. Table D-4 describes those companies using electrolytic processes including brass, cadmium, chromium, copper, gold, iron, lead, nickel, rhodium, silver, tin, tin-lead and zinc plating, as

well as anodizing, electropolishing and electrolytic stripping. Table D-5 refers to electroless plating processes including brass, chromium, copper, nickel, silver and tin electroless plating as well as aluminum, lead, tin and zinc galvanizing. Table D-6 lists companies using miscellaneous processes such as deburring, quenching, coating, cleaning, hardening, drying and forming.

Very few companies responding used only chemical treatment processes. Table D-3 shows that almost all respondents did some kind of electrolytic or electroless plating or coating in addition to chemical pretreatment. Alkaline cleaning and pickling were most frequently reported, followed by solvent degreasing.

Table D-4 shows that almost all cadmium electroplating takes place in Ontario and only one company reported using acid cadmium plating instead of cyanide. Chromium, copper and nickel plating are done in almost all provinces. Only three alkaline chromium processes were reported. At least half of the copper plating is done with cyanide. Gold, silver, rhodium, tin and tin-lead plating are mostly based in Ontario with some exceptions. About 20 percent of zinc coating is done by galvanizing, the remainder by either cyanide or chloride electroplating. Increases in brass, chromium, copper, nickel, tin-lead and zinc chloride electroplating are notable in the results. Zinc cyanide plating has decreased by one-third since 1973.

All electroless plating is done in the provinces of Quebec and Ontario (Table D-5). Electroless nickel and copper plating operations have about doubled since 1973. This partially reflects the emergence of the printed circuit board market and changes in process technology. Zinc galvanizing was reported in every province (Table D-5).

Table D-6 shows that the other procedures most commonly performed in surface finishing shops are mechanical deburring and painting.

4.2 Pollution Control Practices

Tables D-7 to D-10 provide information related to wastewater discharges. Table D-7 summarizes statistics on wastewater generation and discharge, while Table D-8 shows the number of companies practicing wastewater treatment and monitoring. Table D-9 lists the number of companies that monitor and record various pollutant parameters. Table D-10 summarizes wastewater characteristics showing concentrations or concentration ranges for pH, suspended solids and pollutants such as cadmium, chromium, copper, cyanide, lead, nickel and zinc.

Tables D-11 to D-13 present statistics on hazardous wastes generated by surface finishers referring, respectively, to spent process liquors, solvent/oil/paint and process sludges. Table D-14 shows the metal and cyanide contents in process sludge samples. Table D-15 is a summary of air emissions, while Table D-16 shows the concentrations of various pollutants in emissions to the air from plants in Ontario and British Columbia.

Table D-17 is related to chemical recovery/recycling and Table D-18 shows the consumption of chemicals by various processes.

4.2.1 Wastewaters. From Table D-7, it is seen that water use reduction practices have increased in popularity by 50 percent since 1973 and are reported in most provinces. However, some companies still reported dilution as a method of effluent treatment.

Seventy-three percent of surface finishers discharge effluent to municipal sanitary sewers. This is relatively unchanged from the 1973 survey. In Ontario over 95 percent of surface finishing shops discharge to municipal sewers. Two-thirds of the surface finishers reported wastewater discharges of less than 5000 m^3/annum; about one-third discharge over 10 000 m^3/annum. Very few responses relating to volume were received from British Columbia.

Effluent treatment systems (Table D-8) have increased modestly in quantity and quality. Half of all surface finishers report conventional neutralization/settling. Only one-third reported the same in 1973.

Of the 174 companies reported using cyanide in plating solutions only 63 reported the use of electrolytic, high pressure/temperature or other cyanide destruction processes. Chrome is used by 211 companies but, at the most, 158 companies are treating or recovering hexavalent chromium. Ion exchange and evaporation are two recycle processes being used more frequently in Ontario.

Although over half of the companies reported treating effluent, only 15 percent reported any costs. The numbers of companies reporting an annual treatment cost of 0-$10 000, $10 000-$50 000 and over $50 000 were, respectively, 26, 26 and 30 (Table D-8).

A clear trend shown in the data (Table D-8) is the increase in monitoring activity. Only companies that submitted effluent data are included in Tables D-9 and D-10. Some companies indicated that their municipality had such information. At least one-quarter of all surface finishing companies in Ontario and British Columbia monitor their own effluents. Over half are monitored by an outside agency, usually the

municipality (or region). Provincial governments are also active in monitoring in the Atlantic provinces and Quebec, and to a limited extent in Ontario and British Columbia.

The frequency of monitoring was as expected. Companies tend to monitor their pH daily and some other parameters weekly or monthly. Municipalities tend to monitor weekly or monthly. Random sampling was reported as only once or twice in the past five years and this was mainly in Quebec. It appears that the more frequent the monitoring, the better the effluent quality.

The most frequently monitored parameters in effluent were pH, nickel, copper and zinc. The wastewater characteristics (Table D-10) reveal a wide range of effluent quality. Only one-quarter of surface finishers supplied this data.

The wastewater characteristics reported by surface finishers (Table D-10) indicate that most of surface finishing discharges do not meet the federal effluent guidelines for suspended solids, chromium, copper, lead, nickel and zinc, and many of the discharges in Ontario and Quebec do not meet the sewer by-law limits for cadmium, chromium, copper, nickel and zinc.

4.2.2 Hazardous Wastes. Table D-11 indicates that 75 percent of the companies reported the discharge of spent process solutions. Of these, 36 percent (159) discharged straight to a sewer, and another 38 percent discharged first to effluent treatment, then to a sewer. About the same number of companies (153, Table E-8) discharged spent process solutions without treatment in 1973. Surprisingly, the number of companies reporting disposal of spent process solutions off-site has dropped by 40 percent. It appears that more spent process solutions are being discharged to sewer, with or without pretreatment. Half the companies reported volumes of spent process solutions discharged of less than 5 m^3/annum.

Small quantities of solvent, oily or paint waste (Table D-12) are generated by at least one-third of the surface finishers. The frequency of disposal is highly variable but monthly or yearly disposal is most common.

Just over half, 56 percent of the respondants, reported some type of process sludge generation related to surface finishing and effluent treatment (Table D-13). In 1973, 84 percent of surface finishers reported sludge generation; 70 percent of these surface finishers disposed of their sludge off-site. In 1983, off-site sludge disposal was reported at 74 percent. Discharge to sewer now accounts for 14 percent of sludge disposal, while on-site storage or disposal of sludge is 11 percent. The sludges have a high metal content; chromium concentrations can be as high as 14 000 mg/L and zinc as high as 10 000 mg/L. They can also contain up to 160 mg/L of cyanide (Table D-14).

In view of the number of companies using degreasing, alkaline cleaning, effluent neutralization and other processes that produce large quantities of sludge, the figure reported in Table D-13 for companies producing process sludges should be higher than 56 percent. It seems that sewer or on-site disposal is increasing, but many companies did not report their sludge production and disposal practices. Record-keeping appears to be poor; many companies were uncertain of the amounts generated, and the frequency of disposal and disposal site location.

4.2.3 Air Emissions. Air emissions were reported by 33 percent of the surface finishers (Table D-15). Sampling in Ontario and British Columbia indicates that paint solvents and acid mists are the major pollutants in emissions (Table D-16). Volatile solvents and paint fumes are usually controlled with filters and water wash booths. Acids, alkaline mists and particulates are most often treated with scrubbers. A wide variety of other control devices is also employed; exhaust systems are common. Many respondents mentioned receiving a municipal or provincial permit for discharging emissions outside the workplace.

4.2.4 Recovery/Recycling. Less than one-quarter of the companies reported their recovery/recycling practices. Twenty percent of these reported recovering chromium and solvents (Table D-17).

4.3 Future Surveys

In view of existing constraints, the data collected gives a good overview of the surface finishing industry, but a more consistent approach to data collection is needed. Information gaps specific to a certain province may be upgraded by regional or provincial surveys. This would be a better method of collecting details such as costs and quantities.

Plant visits are the ideal means of collecting detailed information but this is obviously not practical for many of the provinces. The questionnaire mail-out has the drawback of sometimes providing sketchy or confused information. Overall, however, the mail-out and telephone follow-up approach met the needs of such a review.

The time and cost of mailing out questionnaires could be reduced by first verifying all potential surface finishers by telephone. A contact name for mailing could be obtained at that time. Follow-up by telephone within a week would expedite the completion of the questionnaire. Response time could be further shortened by completing the questionnaire over the phone, when possible.

5 SUMMARY AND RECOMMENDATIONS

5.1 Summary

1) About 55 percent of the 539 surface finishing operations that responded to the 1983/84 survey questionnaire are located in Ontario and 24 percent are in Quebec. The market for surface finishing is closely related to product manufacturing and has not been increasing. Most of the job and captive operations are small with less than 10 employees. Ontario has some larger operations.

2) The nature and quantity of surface finishing waste has not changed appreciably since 1973. Process changes to reduce the environmental impact of surface finishing operations are not significant. Cyanide is still widely used although some substitution has occurred, e.g., zinc chloride or alkaline plating for zinc cyanide. Electroless nickel and copper plating have doubled but this has had no effect on the wastes generated.

3) Only half of surface finishing operations treat their effluents prior to discharge. Most of the companies use one or more of the recommended water reduction practices. Recovery systems have not increased since 1973.

4) Only 52 percent of all companies using cyanide report monitoring or treating it. Of the companies using chromium, 82 percent report monitoring, recovering or treating it. Of the companies reporting spent process solutions, 38 percent treated their waste while 17 percent practiced off-site disposal.

5) Many companies did not report volumes of sludge produced or disposal methods. All surface finishers are known to produce solid wastes; only 56 percent reported any. Many companies are not maintaining records of sludge quantity and disposal.

6) One-third of the companies reported air emission control. Air emissions reported include acid mists, volatile organic compounds and particulates. However, the significance of these emissions is uncertain.

7) Monitoring of liquid effluents is more frequent than was reported in 1973, both by the companies themselves and by all levels of government. Over half the companies have been monitored. However, enforcement is highly variable between provinces. Enforcement activity also varies between municipalities.

5.2 Recommendations

1) The federal government should continue to assist in the promotion of demonstration projects for recovery technology and substitutes for hazardous chemicals in plating baths.

2) The availability and costs of off-site disposal for hazardous wastes from surface finishing should be studied to determine how to increase their use. On-site disposal sites are increasing and their safety should also be reviewed.

3) The significance of air emissions from surface finishers should be determined.

4) Monitoring and enforcement programs should be standardized, particularly for municipalities within the same province. Local and active enforcement is the most effective means of ensuring compliance. Surface finishers should keep proper records of all liquid and solid wastes and their disposal.

5) Surface finishing plant owners, equipment operators and shop floor workers should be informed of pollution prevention and control practices through participation in training programs developed jointly by government and industry.

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APPENDIX A

CHEMICALS USED IN SURFACE FINISHING THAT ARE INCLUDED IN THE U.S. EPA LIST OF PRIORITY POLLUTANTS

APPENDIX A CHEMICALS USED IN SURFACE FINISHING THAT ARE INCLUDED IN THE U.S. EPA LIST OF PRIORITY POLLUTANTS

Benzene

Carbon tetrachloride (tetrachloromethane)

1,2-dichloroethane

1,1,1-trichloroethane

1,1-dichloroethane

1,1,2-trichloroethane

1,1,2,2-tetrachloroethane

Chloroethane

Chloroform (trichloromethane)

1,1-dichloroethylene

Dichlorodifluoromethane

Naphthalene

Phenol

Bis(2-ethylhexyl) phthalate

Di-n-butyl phthalate

Diethyl phthalate

Anthracene

Ethylbenzene

Methylene chloride (dichloromethane)

Methyl chloride (chloromethane)

Phenanthrene

Tetrachloroethylene

Toluene

Trichloroethylene

Cadmium

Chromium

Copper

Cyanide

Lead

Mercury

Nickel

Silver

Zinc

APPENDIX B

QUESTIONNAIRE USED IN THE SURVEY

APPENDIX B QUESTIONNAIRE USED IN THE SURVEY

SURFACE FINISHING INDUSTRY REVIEW

Company Name _____

Do you have any surface finishing operations in your plant such as plating, anodizing, metal heat treating, coating?

_____ YES _____ NO

SIC Number(s) _____

Address _____

Municipality _____

Province _____

Postal Code _____

Telephone _____

Person Contacted _____

Position _____

Date _____ Interviewer* _____

* Interviewer:
Determine what type of coating operations. Plants with only plastic and/or paint coating operation(s) are not included in the survey.

GENERAL

1. How many years has the business been operating? _____

2. Normal working days per year _____
   Normal shifts per day _____

3. Number of employees in finishing operations/shift _____ Total _____

4. Which of the following surface finishing operations are employed? (check one or more below)

   (a) Mechanical deburring, sand blasting _____

   (b) Hot dip galvanizing (coating a metallic workpiece with another metal by immersion in a molten bath to provide a protective film) _____

   - aluminum _____
   - zinc _____
   - lead _____
   - tin _____

   (c) Electroplating (production of a thin surface coating of one metal on another by electro-deposition. Metal ions in either acidic or alkaline or neutral solutions are reduced on cathodic surfaces) _____

Nickel plating	bright	_____
	semi-bright	_____
	acid	_____
	black	_____
Chromium plating	acidic	_____
	alkaline	_____
Copper plating	cyanide	_____
	pyrophosphate	_____
	sulphate	_____
Zinc plating	cyanide	_____
	chloride	_____
	sulphate	_____

Brass plating		_____
Tin plating	chloride	_____
	acid	_____
	alkaline	_____
Cadmium plating	cyanide	_____
	acid	_____
Gold plating		_____
Silver plating		_____
Lead plating		_____
Iron plating		_____

Other (please specify) _____

(d) Electroless plating (chemical reduction process which depends on the catalytic reduction of a metallic ion in an aqueous solution containing a reducing agent and the subsequent deposition of metal without the use of external electrical energy) _____

Copper		_____
Nickel		_____
Brass		_____
Tin	chloride	_____
	alkaline	_____
Iron		_____
Chromium	acid	_____
	alkaline	_____
Cadmium		_____
Gold	cyanide	_____
	chloride	_____
Silver		_____

Other (please specify) _____

(e) Anodizing aluminum or magnesium (electrolytic oxidation process which converts the surface of a metal to an insoluble oxide) _____

sulphuric _____

chromic _____

(f) Solvent cleaning (process of removing oils and grease from surface of workpiece by the use of organic solvents) _____

vapor - halogenated solvents _____
° solvent(s) used _____
° gallons/year (est.) _____

- non-halogenated solvents _____
° solvent(s) used _____
° gallons/year (est.) _____

liquid - halogenated solvents _____
° solvent(s) used _____
° gallons/year (est.) _____

- non-halogenated solvents _____
° solvent(s) used _____
° gallons/year (est.) _____

(g) Alkaline cleaning (removal of oily dirt or solid soils. Detergent nature of cleaning solution provides most of the cleaning action with agitation of work piece secondary) _____

alkaline solutions used _____
gallons/year (est.) _____

(h) Acid pickling (a solution of an inorganic mineral acid, organic acid or acid salt in combination with a wetting agent or detergent to remove dirt, oil and oxide from metal surfaces) _____

acidic solutions used _____
gallons/year (est.) _____

(i) Acid bright dipping (a specialized form of etching (k) used to remove oxide and tarnish from ferrous and non-ferrous materials) _____

acidic solutions used _____
gallons/year (est.) _____

(j) Stripping Electrodeposits _____

electrolytically _____
immersion only _____

(k) Etching (production of specific design configurations and tolerances on parts (a metal clad plastic in the case of p.c.b.'s) by controlled dissolution of the metal with chemical reagents of etchants) _____

alkaline _____
acid (type used) _____

(l) Chemical conversion coating (coatings are applied to previously deposited metal or base metal) _____

chromating or passivating
chromic acid _____
other _____

metal colouring
phosphating (immersion in dilute solution of phosphoric acid) _____

(m) Coating _____

plastic _____
painting _____
electrostatic painting _____

(n) Electropolishing (process of smoothing or enhancing a metal surface by making it an anode in a suitable electrolyte) _____

(o) Salt bath pot cleaning from metal heat treating operations _____

(p) Quenching from metal heat treating operations _____

brine solutions _____
water and water-based solutions _____

(q) Cyaniding from metal heat treating operations _____

(r) Drying operations for electronic components _____

manufacturing
- halogenated solvent _____
- non-halogenated solvent _____

(s) Making, forming and coating operations from electronic components manufacturing _____

- halogenated solvent _____
- non-halogenated solvent _____

(t) Cleaning operations from electronic components manufacturing _____

cyanides _____
acid _____
alkali _____

5. If the information is not considered proprietary, approximately what is your total output of surface finished products per year? ($/year)

_____

6. What are the major products manufactured at the plant? (printed circuit board, plated screws, hardened metal products, etc.)

_____

7. Are there any water reduction facilities procedures in the plant (for example see below)? Specify.

	YES	NO
- counterflow rinsing		
- conductivity meters in rinse tanks		
- effluent segregation with trenching and piping		
- delay over rinse tanks (manually or by relays) to reduce dragout		
- spray rinsing		
- holding tanks or dams to catch residual spills		

- minimization of seepage losses through floors (by timely maintenance, crack repair, etc.) _____

- other (specify) _____ _____

8. Are liquid effluents collected in trenches or drains?

YES _____ NO _____

Directed to a common collection facility?

YES _____ NO _____

(Sump or tank) Specify _____

9. Are liquid effluents treated?

YES _____ NO _____

Method used

° Chemical Treatment _____

chlorination _____

reduction of chromic acid with sulphur dioxide or meta bisulphite _____

neutralization of acid or alkali _____

other (specify) _____

° Separation or Destruction _____

clarification/gravity settling _____

electrolytic destruction _____

reverse osmosis _____

electrodialysis _____

high pressure temperature hydrolysis _____

ion exchange _____

other (specify) _____

° Evaporation _____

° other (specify) _____

_____

10. Where does the effluent from the system flow?

- to municipal sanitary system _____
- to municipal storm system _____
- to water
  - sea _____
  - lake _____
  - river/stream
    - fresh _____
    - tidal _____
- to ground
  - tile field _____
  - deep well _____
  - seepage pit _____
  - surface _____
- other (specify) _____

11. Is effluent quantity normally monitored?

YES _____ NO _____

If yes, how frequently? _____

By whom? (specify) _____

12. Is effluent quality normally monitored?

YES _____ NO _____

If yes, how frequently? _____

By whom?
- the company _____
- province _____
- municipality _____

other (specify) _____

13. No. of final effluent discharges from plant _____

Identify and list quantity of each effluent stream

	EFFLUENT STREAM	QUANTITY
(A)	_____	_____
(B)	_____	_____
(C)	_____	_____

14. For each final effluent stream listed in 13, establish or estimate (in mg/L except for pH). Where other data is available, please specify.

EFFLUENT STREAM	(A)	(B)	(C)
pH			
S.S.			
chromium			
cadmium			
copper			
nickel			
lead			
zinc			
cyanide			

15. How many people are responsible for the operation of efficient treatment equipment and effluent quality control? _____

16. Can you estimate annual cost of compliance with control requirements? Yes _____ No _____

Approximate cost _____

Cost/Volume effluent _____

HAZARDOUS WASTES

17. Are hazardous wastes:

	YES	NO	VOLUME (gal or ft^3)	FREQUENCY of Disposal (d/wk/mo)	METHOD
Segregated?	___	___	_____	_____	_____
Treated?	___	___	_____	_____	_____
Recovered?	___	___	_____	_____	_____
Disposed?	___	___	_____	_____	_____
Other (specify)	___	___	_____	_____	_____

18. If disposed, what is nature of waste and where is it disposed?

_____

_____

SPENT PROCESS SOLUTIONS (i.e. drainage from process tanks)

19. Where are spent process solutions discharged?

offsite _____

sewer _____

effluent treatment _____

other (specify) _____

20. If spent process solutions are treated before discharge:

What treatment method(s) is/are used? _____

_____

Materials/solutions recovered? _____

_____

21. State the type(s) and estimate the volume(s) of spent process solutions discharged annually.

Spent Process Solution (Description/Type)	Volume Discharged (gal./yr.)
_____	_____
_____	_____
_____	_____
_____	_____

SOLVENTS & OILY WASTES

22. Are solvent or oily wastes generated from processing? (degreasing, machining, heat treating, forming, plastic thermo forming)

	YES	NO	VOLUME (gal or ft^3)	FREQUENCY of Disposal (d/wk/mo)	OPERATION(S) GENERATING WASTES
Solvent wastes	____	____	_____	_____	_____
Oil wastes	____	____	_____	_____	_____

23. Are plant sludges generated?

YES	NO	VOLUME (gal or ft^3)	FREQUENCY of Disposal (d/wk/mo)	OPERATION(S) GENERATING WASTES
____	____	_____	_____	_____

24. Are sludges generated? (If yes, specify items (1), (2), (3))

	YES	NO	(1) VOLUME (gal or cu ft)	(2) DRY CONTENT BEFORE DISPOSAL (%)	(3) FREQUENCY OF DISPOSAL (daily/weekly/ monthly)
from wastewater treatment processes?	____	____	_____	_____	_____
from tank bottoms?	____	____	_____	_____	_____
from treatment of spent process solutions? (specify)	____	____	_____	_____	_____

25. Are these sludges

	YES	NO	METHOD
segregated?	____	____	_____
treated? (specify method)	____	____	_____
recovered? (specify method)	____	____	_____
disposed? (specify method)	____	____	_____

26. Are the sludges monitored?

YES _____ NO _____

Who by? _____

If yes, specify content:

chromium	_____ mg/L
cadmium	_____ mg/L
copper	_____ mg/L
nickel	_____ mg/L
lead	_____ mg/L
zinc	_____ mg/L
cyanides	_____ mg/L
solvents	_____ mg/L

If no, would you agree to give us a sample? _____ YES _____ NO

27. Are any materials reclaimed/regenerated or recovered in any way?

YES NO

Specify _____

AIR EMISSIONS

28. Please identify releases of process emissions to the atmosphere surrounding the plant.

_____

_____

_____

29. Composition and quantity of these emissions to atmosphere.

_____

_____

_____

30. Method used to determine information in (29)

emission factors _____

process material loss estimates _____

direct measurement _____

other (specify) _____

31. Are any control devices used to treat process emissions prior to release to atmosphere?

YES NO

If so, please describe them briefly.

_____

_____

_____

_____

APPENDIX C

CHEMICAL SUPPLIERS CONTACTED

APPENDIX C CHEMICAL SUPPLIERS CONTACTED

The following companies and individuals were contacted for information concerning trends related to production rates:

Company	Individual Contacts
Inco Ltd.	John Schope
Falconbridge Limited	Jack Dupuis
Hanson Inc.	J. P. Temple, J. Sim, J. Hall
Harshaw Ltd.	Eric Knebel
M & T Limited	N. Gregson
Cominco Ltd.	Paul Merritt
MacDermid Chemicals Inc.	Terry Joyce

APPENDIX D

TABULATION OF 1983-84 RESULTS

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Table		Page
D-1	BREAKDOWN OF INDUSTRY BY STANDARD INDUSTRIAL CLASSIFICATION	86
D-2	GENERAL INFORMATION ON SURFACE FINISHING OPERATIONS	87
D-3	NUMBER OF COMPANIES HAVING CHEMICAL TREATMENT PROCESSES	88
D-4	NUMBER OF COMPANIES HAVING ELECTROLYTIC PROCESSES	89
D-5	NUMBER OF COMPANIES HAVING ELECTROLESS PLATING PROCESSES	91
D-6	NUMBER OF COMPANIES USING MISCELLANEOUS PROCESSES	92
D-7	WASTEWATER GENERATION AND DISCHARGE	93
D-8	WASTEWATER TREATMENT AND MONITORING	94
D-9	NUMBER OF COMPANIES THAT KEEP RECORDS OF POLLUTANTS IN WASTEWATERS	95
D-10	WASTEWATER CHARACTERISTICS	96
D-11	HAZARDOUS WASTES - SPENT PROCESS SOLUTIONS	97
D-12	HAZARDOUS WASTES - SOLVENT/OIL/PAINT	98
D-13	HAZARDOUS WASTES - PROCESS SLUDGE	99
D-14	PROCESS SLUDGE CONTENTS	100
D-15	RECORD OF AIR EMISSIONS	101
D-16	POLLUTANT CONTENT IN SAMPLE AIR EMISSIONS	102
D-17	NUMBER OF COMPANIES PRACTICING RECOVERY/RECYCLE	103
D-18	CONSUMPTION OF CHEMICALS BY PROCESS	104

TABLE D-1 BREAKDOWN OF INDUSTRY BY CANADIAN STANDARD INDUSTRIAL CLASSIFICATION (SIC)

SIC	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
				Number of Companies in each SIC					
29 Primary Metal Ind.	-	-	3	10	-	-	1	11	25
30 Fabricated Metal Ind. (includes custom plating)	4	5	66	142	12	1	6	34	270
31 Machinery	1	-	2	10	2	-	1	2	18
32 Transportation equipment	2	1	10	35	7	-	-	6	61
33 Electrical	3	1	31	74	2	-	-	3	114
39 Other manufacturing (includes jewellery, silverware)	-	-	16	25	4	-	-	6	51
Total	10	7	128	296	27	1	8	62	539

TABLE D-2 GENERAL INFORMATION ON SURFACE FINISHING OPERATIONS

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
				Number of Companies					
Years of Operation									
0 - 5	3	-	-	19	-	1	-	10	33
6 - 10	3	2	-	31	-	-	-	6	42
over 10	5	5	-	206	-	-	8	41	265
Captive Operations	6	4	75	166	17	1	2	38	309
Job Shops	5	3	55	100	15	-	6	21	205
Employees in Surface Finishing									
Captive Operations									
1 - 10	3	2	15	99	6	1	2	23	151
11 - 50	1	1	8	43	-	-	-	8	61
over 50	-	-	-	9	-	-	-	1	10
Job Shops									
1 - 10	4	2	8	45	5	-	1	19	84
11 - 50	-	1	5	37	4	-	5	3	55
over 50	-	-	1	9	-	-	-	-	10
Total Surface Finishing Employees									
Captive Operations	35	19	309	3 150	31	4	8	294	3 850
Job Shops	87	79	845	4 174	37	0	146	269	5 637
$/year, Surface Finished Product									
Captive Operations									
10 000 - 100 000	-	-	-	4	-	-	-	3	7
100 000 - 1 000 000	-	-	-	8	-	-	-	7	15
over 1 000 000	-	-	-	17	-	-	1	6	24
Job Shops									
10 000 - 100 000	-	-	-	1	-	-	-	2	3
100 000 - 1 000 000	-	-	-	13	-	-	-	8	21
over 1 000 000	-	-	-	14	-	-	2	2	18

TABLE D-3 NUMBER OF COMPANIES HAVING CHEMICAL TREATMENT PROCESSES

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Degreasing: Vapour	1	1	18 (7)	66 (7)	-	-	2	11 (4)	99 (22)
Degreasing: Liquid	4	1	-	59 (8)	-	-	-	22 (9)	86 (17)
Alkaline Cleaning	6	4 (1)	65 (5)	198 (22)	-	1	5	32 (8)	311 (36)
Pickling	3	2	71 (8)	148 (7)	-	1	7	21 (5)	253 (20)
Bright Dipping	1	1 (1)	4	38 (4)	-	-	-	5 (1)	49 (6)
Immersion Stripping	2	-	3	76 (1)	-	-	4	9	94 (1)
Etching									
- Alkaline	1	1	1	21	-	-	1	2 (1)	27 (1)
- Acid	2	-	1	20 (2)	-	-	-	1	24 (2)
Chromating/Passivating	4 (2)	-	26 (13)	82 (8)	2	-	4	12 (1)	130 (24)
Phosphating	1	1	26 (15)	34 (8)	-	-	-	7 (1)	69 (24)

Note: Numbers in brackets refer to companies having only chemical treatment and employing no other processes.

TABLE D-4 NUMBER OF COMPANIES HAVING ELECTROLYTIC PROCESSES

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Brass	1	-	23	41	-	-	2	10	77
Cadmium									
- Acid	-	-	-	1	-	-	-	-	1
- Cyanide	3	-	-	31	1	-	3	4	42
- Not specified	-	-	-	-	2	-	-	-	2
Chromium									
- Acid	3	2	4	97	1	-	6	20	133
- Alkaline	-	-	-	2	-	-	-	1	3
- Not specified	-	-	49	-	14	-	-	-	63
Copper									
- Cyanide	2	-	4	68	1	-	3	13	91
- Pyrophosphate	-	-	2	3	-	-	-	-	5
- Sulphate	2	-	-	25	-	-	-	4	31
- Not specified	-	-	48	-	7	-	-	-	55
Gold	1	-	-	20	3	-	-	5	29
Iron	-	-	-	-	-	-	-	1	1
Lead	-	-	-	-	-	-	-	1	1
Nickel									
- Bright	1	1	-	100	-	-	4	13	119
- Semi bright	2	1	-	47	-	-	3	6	59
- Acid	-	-	-	16	-	-	-	2	18
- Black	-	-	1	1	-	-	-	-	2
- Not specified	-	-	50	1	9	-	-	-	60

TABLE D-4 NUMBER OF COMPANIES HAVING ELECTROLYTIC PROCESSES (CONT'D)

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Rhodium	-	-	1	7	-	-	-	1	9
Silver	-	-	-	26	5	-	-	6	37
Tin									
- Acid	-	-	-	16	-	-	-	-	16
- Alkaline	-	1	-	9	-	-	-	1	11
- Chloride	-	-	-	-	-	-	-	1	1
- Not specified	-	-	-	-	3	-	-	-	3
Tin-lead	-	-	-	6	1	-	-	-	7
Zinc									
- Alkaline	-	-	-	5	-	-	-	-	5
- Chloride	-	-	-	37	-	1	-	2	40
- Cyanide	-	1	3	28	3	-	3	3	41
- Sulphate	-	-	-	2	-	-	-	-	2
- Not specified	1	-	20	2	2	-	-	-	25
Anodizing									
- Sulphuric	1	1	-	27	-	-	2	4	35
- Chromic	2	-	-	6	-	-	-	2	10
Electropolishing	-	-	-	7	-	-	1	1	9
Electrolytic stripping	2	-	-	30	-	-	2	13	47

TABLE D-5 NUMBER OF COMPANIES HAVING ELECTROLESS PLATING PROCESSES

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Brass	-	-	-	1	-	-	-	-	1
Chromium									
- Alkaline	-	-	-	1	-	-	-	-	1
- Not specified	-	-	-	1	-	-	-	-	1
Copper	-	-	14	17	-	-	-	-	31
Nickel	-	-	14	13	-	-	2	-	29
Silver	-	-	-	2	-	-	-	-	2
Tin	-	-	-	6	-	-	-	-	6
Galvanizing									
- Aluminum	-	-	-	2	2	-	-	1	5
- Lead	-	-	-	-	-	-	-	1	1
- Tin	-	-	1	3	-	-	-	1	5
- Zinc	1	1	8	9	2	-	2	5	28

TABLE D-6 NUMBER OF COMPANIES USING MISCELLANEOUS PROCESSES

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Mechanical Deburring	5	5	-	107	-	-	4	24	145
Salt Bath Pot Cleaning	1	-	-	13	-	-	-	-	14
Quenching									
- Brine	1	-	-	10	-	-	-	2	13
- Water	2	2	-	26	-	1	-	13	44
Cyanide Hardening	-	-	-	10	-	-	1	-	11
Coating									
- Plastic	-	-	-	13	-	-	-	2	15
- Painting	3	2	37	75	-	-	2	18	137
- Electrostatic Painting	-	-	-	38	-	-	1	4	43
Electronic Components									
Drying									
- Non Halogenated Solvent	1	-	-	3	-	-	-	1	5
- Halogenated Solvent	-	-	-	1	-	-	-	-	1
Forming									
- Non Halogenated Solvent	-	-	-	3	-	-	-	-	3
- Halogenated Solvent	-	-	-	2	-	-	1	-	3
Cleaning of Electric Components									
- Acid	-	-	-	4	-	-	-	-	4
- Alkaline	1	-	-	5	-	-	-	1	6
- Cyanide	1	-	-	6	-	-	-	-	7

TABLE D-7 WASTEWATER GENERATION AND DISCHARGE

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Water Use Reduction				Number of Companies					
- Counter Flow Rinsing	2	1	-	130	-	-	1	13	147
- Conductivity Meters	-	2	-	39	-	-	1	3	45
- Effluent Segregation	-	1	-	84	-	1	1	13	100
- Delay to Reduce Dragout	6	4	-	136	-	1	6	20	173
- Spray Rinsing	6	3	1	108	-	-	5	21	144
- Tanks for Spills	4	1	-	143	-	1	6	19	174
- Floor Maintenance	4	2	-	134	-	1	3	13	157
- Other	1	-	1	22	-	-	-	2	26
Wastewater Volume Discharged				1000 m^3/year					
1 - 5	4	4	89	46	2	-	1	4	150
6 - 10	-	-	4	5	-	-	-	-	9
over 10	-	-	35	72	2	-	1	6	116
Receiver				Number of Companies					
- Municipal Sanitary	4	3	88	211	25	1	6	25	363
- Municipal Storm	3	2	11	11	-	-	1	5	33
- Sea	3	2	-	-	-	-	-	5	10
- Lake	-	1	-	3	-	-	-	-	4
- Fresh River	1	3	6	6	-	-	1	1	18
- Tidal River	1	-	1	1	-	-	-	-	3
- Tile Field	1	-	1	1	-	-	-	1	4
- Deep Well	1	-	-	1	-	-	-	-	2
- Seepage Pit	1	-	-	2	-	-	-	2	5
- Ground Surface	1	-	-	-	-	-	-	-	1
- Other	1	-	5	15	-	-	-	2	23

TABLE D-8 WASTEWATER TREATMENT AND MONITORING

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Wastewater Treatment									
- Cyanide Destruction	-	-	7	40	-	-	-	2	49
- Chromium Reduction	3	-	18	66	-	-	2	17	106
- Neutralization	1	2	73	160	-	1	3	29	269
- Settling	1	-	37	97	-	1	2	18	156
- Electrolytic Destruction	-	-	-	4	-	-	-	1	5
- Reverse Osmosis	-	-	-	2	-	-	-	-	2
- Electrodialysis	-	-	1	3	-	-	-	-	4
- Ion Exchange	-	-	-	26	-	-	-	-	26
- Evaporation	-	-	-	19	-	-	-	1	20
- High Pressure/ Temperature Hydrolysis	-	-	-	2	-	-	-	-	2
- Dewatering	-	-	6	25	-	-	-	1	32
Annual Treatment Costs $/annum									
0 - 10 000	3	1	-	19	-	-	1	2	26
10 000 - 50 000	-	-	-	26	-	-	-	-	26
over 50 000	1	-	-	28	-	-	-	1	30
Monitored by:									
- Company	1	-	1	112	-	-	3	15	132
- Municipality	-	-	61	133	-	1	5	17	217
- Province	4	3	8	20	-	-	-	2	37
- Environment Canada	-	-	6	-	8	-	-	1	15
Monitoring Frequency									
- Daily	-	-	-	85	-	-	-	-	85
- Weekly	-	-	-	31	-	-	-	-	31
- Monthly	-	-	-	48	-	-	2	-	50
- Yearly	-	-	8	18	7	-	-	-	33
- Random	-	-	70	14	1	-	-	-	85

TABLE D-9 NUMBER OF COMPANIES THAT KEEP RECORDS OF POLLUTANTS IN WASTEWATERS

Pollutant	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
				Number of Companies					
Discharge to Sanitary Sewer									
- pH	-	-	-	122	-	1	2	11	136
- Suspended Solids	-	-	33	34	1	1	-	5	74
- Cadmium	-	-	11	20	8	-	1	3	43
- Chromium	1	-	49	71	8	1	1	6	137
- Copper	-	-	35	58	8	-	1	7	109
- Cyanide	-	-	35	36	-	-	-	4	75
- Lead	-	-	13	21	8	-	1	4	47
- Nickel	-	1	42	58	8	-	1	4	114
- Zinc	2	1	39	64	8	1	1	6	122
Discharge to Storm Sewer or Water Source									
- pH	1	1	-	18	-	-	-	5	25
- Suspended Solids	-	-	9	5	-	-	-	-	14
- Cadmium	1	-	4	3	-	-	-	-	8
- Chromium	5	1	19	10	-	-	-	1	36
- Copper	5	1	13	9	-	-	-	-	28
- Cyanide	2	-	7	6	-	-	-	1	16
- Lead	1	1	11	3	-	-	-	2	18
- Nickel	2	1	17	10	-	-	-	-	30
- Zinc	4	2	18	10	-	-	-	2	36

TABLE D-10 WASTEWATER CHARACTERISTICS

Pollutant	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.
			Average Concentration in mg/L					
Discharge to Sanitary Sewer								
- pH	-	-	5.5 - 9.5	7.4	-	9.1	7.4	5.5 -9.0
- Suspended Solids	-	-	1.9 - 440	0.1 - 600	200	50.0	-	10 - 500
- Cadmium	-	-	0 - 6.2	0 - 8	0 - 0.9	-	0.0	0 - 0.3
- Chromium	2.2	-	0 - 50.5	0 - 10.5	0.4 - 89.2	0.1	0.1	0.1 - 3.6
- Copper	-	-	0 - 36	0 - 14.6	0.1 - 4.1	-	0.3	0 - 1.7
- Cyanide	-	-	0 - 18	0 - 30	-	-	-	0 - 3.0
- Lead	-	-	0 - 11.8	0 - 5	0 - 27.5	-	0.0	0 - 1.0
- Nickel	-	0.9	0 - 12	0 - 14.5	3.2 - 1185	-	1.2	0 - 45
- Zinc	0.05	0.1	0 - 40	0 - 70	0.1 - 1.3	2.5	1.5	0 - 7.0
Discharge to Storm Sewer or Water Source								
- pH	5.2	7.0	5.5 - 9.5	0.7 - 10	-	-	-	7.0 - 8.5
- Suspended Solids	-	-	0.2 - 780	7.8 - 50	-	-	-	-
- Cadmium	0.2	-	0 - 2.1	0.1 - 0.5	-	-	-	-
- Chromium	0.3 - 518	0.1	0 - 50	0.1 - 4	-	-	-	0.0
- Copper	0.1 - 3.4	0.1	0 - 2.5	0.1 - 3	-	-	-	-
- Cyanide	0.2 - 2.6	-	0 - 11.5	0 - 2	-	-	-	1.0
- Lead	0.4	1.2	0 - 1.5	0.1 - 0.5	-	-	-	0.1
- Nickel	0.2 - 25	0.9	0 - 23.5	0.1 - 6	-	-	-	-
- Zinc	0.005 - 54	0.12 - 22.3	0 - 41.5	0.1 - 10	-	-	-	0.0

TABLE D-11 HAZARDOUS WASTES - SPENT PROCESS SOLUTIONS

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Volume of Spent Process Solutions Discharged				Number of Companies					
1 - 5 m^3/annum	7	-	131	52	-	-	-	9	199
6 - 10 m^3/annum	-	1	15	22	-	1	1	6	46
over 10 m^3/annum	-	-	22	126	-	-	3	8	159
Spent Process Solution				m^3/annum					
Acid	1.2	-	1 901	206 740	-	-	276	1 598	210 516
	(4)		(95)	(138)			(4)	(16)	(257)
Alkaline	-	-	983	9 724	-	-	40.0	891	11 638
			(75)	(73)			(2)	(10)	(160)
Chrome	4.3	-	31.4	12 977	-	-	-	5.5	13 018
	(3)		(15)	(21)				(4)	(43)
Cyanide	0.2	-	17.5	3.7	-	-	-	-	21.4
	(1)		(7)	(2)					(10)
Paint/Solvents	-	-	-	342	-	-	-	-	342
				(11)					(11)
Discharged to				Number of Companies					
Sewer	4	4	81	54	-	1	2	13	159
Treatment	4	3	6	122	-	1	2	27	165
Offsite	2	1	4	64	-	-	3	2	76
Other	1	-	5	26	-	-	-	5	37

* Figures in brackets indicate number of companies reporting discharges.

TABLE D-12 HAZARDOUS WASTES - SOLVENT/OIL/PAINT

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Solvent and Oily Waste Volume									
1 - 2.5 m^3/annum	1	1	30	50	-	-	1	10	93
2.6 - 5 m^3/annum	1	-	9	13	-	-	-	1	24
over 5 m^3/annum	-	-	10	39	-	-	-	4	53
Paint Sludge Volume									
1 - 2.5 m^3/annum	2	1	2	17	-	-	1	2	25
2.6 - 5 m^3/annum	-	-	-	7	-	-	-	1	8
over 5 m^3/annum	-	-	1	8	-	-	1	2	12
Frequency of Disposal									
Daily	-	-	-	6	-	-	-	2	8
Weekly	-	-	-	9	-	-	-	2	11
Monthly	-	3	-	48	-	-	-	13	64
Every Few Months	-	-	-	24	-	-	-	3	27
Yearly	3	4	-	60	-	-	1	6	74

TABLE D-13 HAZARDOUS WASTES - PROCESS SLUDGE

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Volume Generated				Number of Companies					
1 - 5 m^3/annum	4	4	35	68	-	-	2	15	128
6 - 50 m^3/annum	1	-	14	31	-	2	1	2	51
over 50 m^3/annum	-	-	5	25	-	-	-	3	33
Total Volume Generated				m^3/annum					
	19.5	1.3	1 312	10 618	-	68	23	1 224	13 266
Discharged to				Number of Companies					
Sewer	-	1	39	3	-	-	-	-	43
Onsite	2	-	18	7	-	-	-	5	32
Offsite	5	3	23	131	32	1	5	16	216
Monitoring of Sludge	-	-	-	35	-	-	3	1	39
Monitored by									
Company	-	-	-	18	-	-	1	-	19
Disposal Service	-	-	-	27	-	-	1	-	28
Municipality	-	-	-	12	-	-	1	-	13
Number of companies willing to participate in sludge sampling program	9	5	-	104	-	-	7	17	142

Note: The sludges include tank bottoms, spent process solution treatment and effluent treatment sludges.

TABLE D-14 PROCESS SLUDGE CONTENTS

Ontario - All Reported Data (mg/L)

Chromium	Cadmium	Copper	Nickel	Lead	Zinc	Cyanide
13 960.0	50.0	980.0	259.0	105.0	10 400.0	160.0
2 720.0	4.0	308.0	161.0	30.0	230.0	10.0
1 100.0	0.0	285.0	47.0	29.0	200.0	0.5
1 010.0		75.0	30.0	0.2	179.0	0.2
63.0		2.5	10.0		55.0	
2.5		1.0	2.5		5.2	
1.7		0.8	1.2		4.0	
1.0		0.5	0.2		1.0	
0.3		0.0	0.1		0.1	
0.2						
0.2						

British Columbia - All Reported Data (mg/L)

Lead	Zinc
5.0	5.0

TABLE D-15 RECORD OF AIR EMISSIONS

Process	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Emissions									
Acid	-	-	-	53	-	-	-	4	57
Alkaline	-	-	-	20	-	-	1	2	23
Chrome	-	1	-	37	-	-	1	3	42
Dust (including particulates)	-	-	-	-	-	-	1	11	12
Paint	-	-	-	22	-	-	2	3	27
Solvent	-	-	-	18	-	-	1	2	21
Control Device in Use (Total)	-	1	-	163	-	-	5	70	239
Exhaust System	-	-	-	51	-	-	-	20	71
Condenser	-	1	-	3	-	-	-	-	4
Scrubber	-	-	-	62	-	-	-	9	71
Water Wash Booths	-	-	-	16	-	-	1	4	21
Cyclone	-	-	-	3	-	-	1	8	12
Mist Eliminator	-	-	-	5	-	-	1	3	9
Dust Collector (Baghouse)	-	-	-	2	-	-	1	23	26
Filter (Dry paint booths)	-	-	-	17	-	-	1	3	21
Electrostatic Precip.	-	-	-	1	-	-	-	-	1
Incineration	-	-	-	3	-	-	-	-	3

TABLE D-16 POLLUTANT CONTENT IN SAMPLE AIR EMISSIONS

ONTARIO		
Inorganic		
NO_x	400.0	ppm
H_2SO_4	8.0	lb/day
HCl	10.0-30.0	ppm
Ammonium Chloride	10.0	mg/m^3
Nickel	0.1	mg/m^3
Zinc Oxide	5.0	mg/m^3
Organic		
Formaldehyde	0.2	ppm
Volatile Organic Compounds	50.0-470.0	ppm
Kerosen	2.0	ppm
Paint Solvent	24 000.0	cfm
Trichloroethylene	19.0	lb/day
Toluene	290.0	gal/yr
Xylene	25.0	mg/m^3
Varsol	0.5	lb/hr
Xylol	1 500.0	gal/yr
Particulates		
Oil in Air	1 080.0	gal/yr
Oil Mist	5.0	mg/m^3
Acids	24 000.00	cfm
BRITISH COLUMBIA		
Particulates	6.9-59.3	mg/m^3
HCl	6.4-45.0	mg/m^3
Zinc	2.3-13.7	mg/m^3
Oil mist	11.4	mg/m^3

TABLE D-17 NUMBER OF COMPANIES PRACTICING RECOVERY/RECYCLE

Chemicals Recovered/Recycled	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Acid	-	-	-	7	-	-	-	2	9
Alkaline	-	-	-	2	-	-	-	-	2
Cadmium	-	-	-	-	-	-	-	1	1
Chrome	-	-	-	21	-	-	1	3	25
Copper	-	-	-	9	-	-	-	2	11
Magnesium	-	-	-	-	-	-	-	1	1
Nickel	-	-	-	12	-	-	1	1	14
Precious Metals	-	-	2	12	-	-	-	2	16
Solvents/Oil	-	-	7	21	-	-	-	12	40
Miscellaneous	-	1	-	4	-	-	-	-	-

TABLE D-18 CONSUMPTION OF CHEMICALS BY PROCESS

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
				m^3/annum					
Degreasing Vapour									
Halogenated Solvent	-	-	-	866	-	-	2	143	1 011
Non Halogenated Solvent	-	-	-	51	-	-	-	-	51
Degreasing Liquid									
Halogenated Solvent	-	-	-	352	-	-	-	15	367
Non Halogenated Solvent	-	-	-	442	-	-	-	138	580
Alkaline Cleaning Solutions	-	-	-	9 437	-	-	27	68	9 532
Acid Cleaning Solutions (Pickling & Bright Dipping)	-	-	-	12 095	-	-	48	380	12 523

APPENDIX E

TABULATION OF 1973 RESULTS

APPENDIX E TABULATION OF 1973 RESULTS

Table		Page
E-1	SURVEY RESPONSE AND GENERAL INFORMATION	108
E-2	NUMBER OF COMPANIES HAVING CHEMICAL TREATMENT PROCESSES	109
E-3	NUMBER OF COMPANIES HAVING ONLY CHEMICAL TREATMENT PROCESSES	110
E-4	NUMBER OF COMPANIES HAVING PLATING PROCESSES	111
E-5	WASTEWATER GENERATION AND DISCHARGE	112
E-6	WASTEWATER TREATMENT AND MONITORING	113
E-7	WASTEWATER RECORDS	114
E-8	HAZARDOUS WASTES	115
E-9	CONSUMPTION OF CHEMICALS BY PROCESS	116

TABLE E-1 SURVEY RESPONSE AND GENERAL INFORMATION, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Number of:									
Questionnaires mailed	-	15*	272	572	-	-	165**	64	1 088
Replies received	-	9*	150	311	-	-	88**	51	609
Applicable	-	4*	62	217	-	-	28**	30	341
Captive Operations	2	1	49	164	9	-	3	13	241
Job Shops	1	-	13	53	2	2	12	17	100
Employees in Surface Finishing									
Captive Operations									
1 - 10	2	1	30	85	5	-	3	7	133
11 - 50	-	-	12	52	3	-	-	5	72
over 50	-	-	7	27	-	-	-	1	35
Job Shops									
1 - 10	1	-	9	19	-	-	-	-	29
11 - 50	-	-	3	26	-	-	-	-	29
over 50	-	-	1	8	-	-	-	-	9

* combined NS & NB

** combined MAN., SASK., ALTA

TABLE E-2 NUMBER OF COMPANIES HAVING CHEMICAL TREATMENT PROCESSES, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Degreasing: Vapour	-	-	22	95	3	-	4	9	133
Degreasing: Liquid	-	-	12	27	1	-	4	2	46
Alkaline Cleaning	1	1	28	114	3	-	6	12	168
Pickling	1	-	29	82	-	-	8	16	136
Bright Dipping	-	-	14	39	3	-	-	5	61
Immersion Stripping	-	-	15	41	4	2	3	9	74
Etching									
- Alkaline	-	-	-	-	-	-	-	-	-
- Acid	-	1	9	30	2	1	3	3	49
Chromating/Passivating	-	-	27	73	4	-	4	8	116
Phosphating	-	-	19	69	3	-	3	5	99

TABLE E-3 NUMBER OF COMPANIES HAVING ONLY CHEMICAL TREATMENT PROCESSES, 1973*

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Degreasing: Vapour	-	-	7	21	1	-	1	2	32
Degreasing: Liquid	-	-	-	-	-	-	-	-	-
Alkaline Cleaning	-	-	6	35	-	-	1	-	42
Pickling	-	-	6	17	1	-	3	3	30
Bright Dipping	-	-	1	4	-	-	-	1	6
Immersion Stripping	-	-	2	4	-	-	-	-	6
Etching									
- Alkaline	-	-	-	-	-	-	-	-	-
- Acid	-	-	-	-	-	-	-	-	-
Chromating/Passivating	-	-	3	15	-	-	-	1	19
Phosphating	1	-	6	36	1	-	1	2	47

* These companies have no electroplating, no electroless plating, no galvanizing, no anodizing, no electropolishing, no electrolytic stripping.

TABLE E-4 NUMBER OF COMPANIES HAVING PLATING PROCESSES, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
Electroplating									
Brass	-	-	4	19	1	-	1	4	29
Cadmium									
Not specified	1	-	12	40	1	-	2	3	59
Chromium									
Not specified	1	-	12	75	2	2	9	16	117
Copper									
Cyanide	-	-	16	57	2	1	4	9	89
Not specified	-	-	4	16	1	-	3	4	28
Gold	-	-	7	10	2	-	-	3	22
Lead	-	-	4	3	-	-	-	-	7
Nickel									
Bright	-	-	14	73	3	1	6	12	109
Semi-bright	-	-	6	37	1	-	2	5	51
Silver	-	-	10	21	3	-	-	6	40
Tin									
Not specified	-	-	8	28	1	-	-	1	38
Zinc									
Cyanide	-	-	11	41	2	-	3	5	62
Not specified	-	-	1	11	1	-	-	-	13
Anodizing									
Sulphuric	-	1	11	24	1	-	1	3	41
Chromic	-	-	4	9	1	-	-	-	14
Electropolishing	-	-	2	4	-	-	-	-	6
Cyanide hardening	-	-	6	8	-	-	1	3	18
Electroless Plating									
Copper	-	-	8	7	-	-	-	2	17
Nickel	-	-	7	7	-	-	1	2	17

TABLE E-5 WASTEWATER GENERATION AND DISCHARGE, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Water Reduction									
Counter Flow Rinsing	-	-	7	61	1	1	3	8	80
Conductivity Meters	-	-	2	24	1	-	-	6	33
Effluent Segregation	-	-	-	-	-	-	-	-	-
Delay to Reduce Dragout	-	-	-	-	-	-	-	-	-
Spray Rinsing	1	-	8	47	2	1	4	7	70
Tanks for Spills	-	-	-	-	-	-	-	-	-
Floor Maintenance	-	-	-	-	-	-	-	-	-
Other	-	-	10	55	-	1	-	2	68
Wastewater Discharged to:									
Municipal Sanitary	2	1	37	150	6	1	6	15	218
Other	1	-	17	44	4	1	7	12	86

TABLE E-6 WASTEWATER TREATMENT AND MONITORING, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Wastewater Treatment									
Cr Reduction	-	-	4	46	-	-	-	2	52
Neutralization	-	-	8	68	3	-	1	6	86
Settling	-	-	13	79	5	-	5	12	114
Ion Exchange	-	-	-	9	-	-	-	-	9
Evaporation	-	-	-	5	-	-	-	-	5
Dewatering	-	-	3	10	-	1	-	-	14
Monitored by:									
Municipality	-	-	14	48	2	-	2	5	70
Province	1	-	12	45	2	-	4	7	72

TABLE E-7 WASTEWATER RECORDS, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Discharge to Sanitary Sewer									
pH	-	1	13	83	1	-	1	10	109
Suspended Solids	-	-	7	41	-	-	-	2	50
Cadmium	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	-	-	-
Cyanide	-	-	3	34	-	-	-	4	41
Lead	-	-	-	-	-	-	-	-	-
Nickel	-	-	-	-	-	-	-	-	-
Zinc	-	-	-	-	-	-	-	-	-
Metals	-	-	6	47	-	-	-	4	57

TABLE E-8 HAZARDOUS WASTES, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
					Number of Companies				
Spent Process Solutions Discharged to:									
Offsite	1	-	16	89	3	1	5	9	124
Effluent Treatment	-	-	14	98	1	-	2	12	130
Sewer	2	1	37	84	5	1	10	13	153
Process Sludge Disposal									
Offsite	2	-	24	147	4	2	9	15	203
Other	-	1	25	42	4	-	4	8	84
Materials/Solutions Recovered	1	-	23	64	4	1	8	10	111

TABLE E-9 CONSUMPTION OF CHEMICALS BY PROCESS, 1973

	N.S.	N.B.	QUE.	ONT.	MAN.	SASK.	ALTA.	B.C.	CANADA
				Total Volume, m^3/annum					
Degreasing Vapour									
Halogenated Solvent	-	-	838	1 388	117	-	8.7	85	2 437
Non Halogenated Solvent	-	-	1.8	464	-	-	-	-	466
Degreasing Liquid									
Halogenated Solvent	-	-	62	45	-	-	1.4	-	108
Non Halogenated Solvent	-	-	-	-	-	-	-	-	-
Alkaline Cleaning Solutions	-	-	142	708	4.4	-	7.9	22	884
Acid Cleaning Solutions (Pickling & Bright Dipping)	-	-	2 127	4 796	21	-	20	2 197	9 161